大正六年參月
出版第一〇九號

# 農事試驗場特別報告

第拾五號

## 一點大螟蛾ニ關スル研究

臺灣總督府農事試驗場

# ADDITIONS AND CORRECTIONS.

(1), line 15, for Life-Histry read Life-History.
4 line 15, strike out "Cassini Id." and put period after part.
8 line 28, for a73 read 273.
36 line 8, insert "annual" before "loss of".
40 line 12, for foremost read lowermost; and line 7 from bottom, for bepends read depei
41 line 16, for completly read completely.
43 line 14, insert "of" after number.
52 line 6, for bread read broad.
53 line 7, for 0.35-0.6mm. read 0.35-0.36mm.; and line 13, for 2.31-0.30mm. read 0.31-0.30mm.
59 line 3 from bottom, for destributing read distributing.
67 line 8, for "as follow" read "as follows".
68 line 16, for "Ceraphron base" read "Ceraphron has".
70 line 14, for Lenglh read Length.
72 line 6, for p.407(4) read p.407(27); and line 9, add "27" before Blackish brown.
75 line 7, for 1.015mm. read 0.015mm.
77 line 1, put comma after 2-jointed.
88 line 10 from bottom, strike out "and dryness....temperature".
93 line 4 from bottom, for 30.0 read 30.9; and line 6 from bottom, for 87.0 read 87.9.
104 line 1 from bottom, for 11 read 1.
106 row 13 from right, for 0 read . .
107 row 4 from right and line 5, for 0 read . .; row 6 from right, for 4 read 14; and row 5 from right, for 1 read .
108 line 2 from bottom, for 25 read 23.
112 row 2 from left in Table, for 39 read 30.
121 row 2 from left in Table, for 31 read 13.
124 line 16, for "out off" read "cut off"; and row 3 from right in Table, for 41 read 42.
125 line 8, insert "killed" after are; and line 3 from bottom, for schaedl. read Schaedl..
129 line 6 from bottom, for femara read femora.
131 line 8 from bottom, insert "midway" after nearly.
138 line 4, for pedical read pedicel.
143 line 4, for gonapophysis read gonapophyses.
149 line 14, for "joint; the second" read "jointed; the second".
165 line 15 from bottom, for sympoms read symptoms.
167 line 14, strike out "(pl. VIII. fig. 7.)".
171 line 6, for *Fripternimorpha* read *Eripternimorpha*.
176 lines 1, 2, 14, 15 & 16 from bottom, for joint read joints; and lines 3 & 13 from bottom, for spur read spurs.
178 line 16, for hut read but.
179 lines 3 and 4, for joint read joints.
186 line 17 from bottom, insert "of life" after Length.
189 line 13 from bottom, insert "ones" after dead.
191 line 10, for alway read always.
197 line 8 from bottom, for observatien read observations.
199 row 1 from right and line 1, for Condnued read Continued.
211 line 6, for abont read about.
221 line 9, for accustim read accustom.
226 line 12, for expences read expenses.
227 line 3, for results read results.
232 line 1, for 1608 read 1908.
239 line 13, for propable read probable.
243 line 12, for no read on; and line 20, insert "to" before ascertain.
Map strike out "Cassini 1s."
Plate X for Plaie read Plate.
Illustration of Plate XI lines 1, 2, 3, 6 & 7, insert "♀" before "(enlarged)"; and lines 4 and 5, insert "♂" before "(enlarged)".
Plate XVI for Flate read Plate.

# PREFACE.

From ancient times, in Japan, rice has been as indispensable an article of food, as wheat is to European peoples. Paddy cultivation has increased year by year, and up to the present, it has been practised more skilfully and scientifically in Japan than in any other country. The most careful attention is given by farmers to the slightest damage to the crop, and for many years the pests of paddy have been studied, especially injurious insects. Up to the present time, hundreds of species of injurious insects have been noted by our students, and although several serious insect pests of paddy are known Itten-O-Meiga (*Schoenobius incertellus* WLK.) always has been by far the most serious of these. Frequent occurrences of other serious pests, such as, Paddy Hispa, Paddy Lema, Paddy leaf-hoppers, and Grass-hoppers, have in no way lessened the destructiveness of the paddy Pyralid (Itten-O-Meiga), though its injuries have sometimes been overshadowed by the more serious depredations of the other species.

In Japan (not including Formosa), numbers of investigations of this pest have been made by the Department of Agriculture and Commerce, and also by the Agricultural Experiment Stations of several Prefectures. From the results of these, several methods of control have been indicated, and they were put in practice in the fields, but the injuries have not been visibly decreased. Itten-O-Meiga is still the most serious pest of paddy, and supplementary investigations are being made by several entomologists. In Formosa some measures which are practiced to destroy the insect in Japan have been adopted, but with less effect than in Japan. The annual damage caused by Itten-O-Meiga varies little, the loss of the crop averaging about a million bushels each year.

The serious ravages of the paddy Pyralid in recent times, notably in portion of the southern part of Formosa have necessitated

Federated Malay States ; to Dr. J. C. Konigsberger, Entomologist of Batavia, Java. From these statements concerning this insect in their countries have been received, which have of great use in this work.

As regards the illustrations ; the coloured plates were drawn by Mr. M. Maki, Assistant Entomologist ; the photographs were taken by Mr. S. Inamura, Assistant Entomologist ; to both of whom thanks must be expressed for their excellent work.

Most cordial acknowledgments are due to Hon. M. Takada. Chief of the Bureau of Agriculture, Forestry, Commerce and Industry, Government of Formosa ; to Dr. U.Ogawa, Chief of the Division of Agriculture; and to Dr. Y.Fujine, Acting Chief of the Agricultural Experiment Station, Formosa, for the great trouble they have taken in matters connected with the investigation.

The auther must also render grateful thanks to Dr. C. J.Gahan Keeper of the Entomological Department of the British Museum (Natural History), London, for giving him free access to the collections, and to Mr. Hartley Durrant, Microlepidopterist in the British Museum, for assistance in matters connected with the preparation of the report.

Lastly, most cordial acknowledgments are due to Prof. S. Matsumura, Rigaku Hakushi, for his kind counsel and advice.

Angust, 1915.



investigations, supplementary to those previously made by the Department of Agriculture and Commerce of Japan, and by the Agricultural Experiment Station of Formosa. In 1909, three headquarters were established in Taihoku, Taichyu, and Hozan (which belong respectively to the different life-areas of Formosa) for the "Itten O-Meiga investigation".

During the years, 1909-1911, special attention was given to field work, though such laboratory investigations as were possible were conducted. The principal results have been annually published in the Report of Investigation of Injurious Insects (Gaichiu Chosa Hokoku), vols. I, II, & III, of the Bureau of Agriculture, Forestry, Commerce and Industry. In 1912, the headquarter at Hozan was removed to Ako, and special studies were undertaken in the laboratory and in the field.

The present report of the "Itten-O-Meiga investigation" in Formosa has become so lengthy that it has been found impossible to include in it the whole of the informations obtained from other countries, but the results of all investigations to date, and all known data recorded in foreign countries are mentioned, and from these the conclusions are given.

Three assistants were employed in the work, and two others were engaged during 1909. Auther has assisted by Messrs. T. Seki, Y. Kiiri, S. Inamura, M. Kimura and Y. Moritsugu, to whom his thanks are due for the cordial help always afforded him, he is also indebted to so many officers of different Prefectures in Formosa, that it would be invidious to mention names.

Sincere acknowledgments are due to Mr. E. E. Green, late Government Entomologist of Ceylon ; to Mr. J. Bainbrigge Fletcher N. F. L. S., F. E. S., F. Z. S., Government Entomologist of India ; to Mr. F. W. Taylor, Chief of the Department of Agriculture, Philippines ; to Mr. K. D. Schroff, Agriculturist of the Government of Burma ; to Mr. L. Lewton, Agriculturist of the Government of the

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## Chapter I.

## Classification and Synonymy.

### Schoenobius incertellus Wlk.

**(Itten-O-Meiga.)**

This insect is a moth belonging to the family *Pyralidae*. Sir G. F. Hampson, in his Fauna of British India, Lepidoptera, vol. iv (1896), places the species in the subfamily *Schoenobiinae*, and in this he is followed by Prof. S. Matsumura, in Catalogue Insectorum Japonicum, vol. I (1905).

The genus *Schoenobius* was founded by P. A. J. Duponchal in 1836 in his Hist. Nat. Lep. de France, Tom. X, p. 312-13, and the species was described in 1863 by Francic Walker in his Catalogue of Heterocera in the British Museum under the name of *Chilo incertulas* (male), and *Tipanoea bipunctifera* (female)-he described it as the male; again in the same year (1863) he redescribed the insect as *Chilo gratiosellus* (female) and *Catagela* (*?*) *admotella* (male), and in the same year, by P. C. Zeller in his Chilonidarum et Crambidarum genera et species, again described the species under the name *Schoenobius minutellus* (male) and *punctellus* (female).

In 1896 Sir G. F. Hampson adopted, in his Fauna of British India the names *Schoenobius incertellus* and *bipunctifer*. At the same time he placed *gratiosellus* Wlk. and *punctellus* Zell. as synonyms of the latter, and *minutellus* Zell. as synonyms the former. Owing to the great difference between the male and the female, the sexes of this species have been described separately by several entomologists, while in Japan the female and male were acknowledged as *Schoenobius bipunctifer* Wlk., and no one noticed that the male coincided with the description of *Schoenobius incertellus* Wlk.

In 1913 I determined the male moth as *incertellus* Wlk., accor-

ding to Hampson's description, and sent several specimens which had been bred in the laboratory in Formosa to Sir G. F. Hampson asking him to compare them with Walker's types. In his letter of reply Sir G. F. Hampson informed me that the male agreed with *incertellus*, and the female with *bipunctifer*.

I was afterwards able myself to compare the Formosan and Japanese specimens with Walker's and Zeller's types in the British Museum; and these can be no doubt that *bipunctifer* is certainly the female of *incertellus*.

Itten-O-Meiga has therefore the following synonymy:

*Schoenobius incertellus* Wlk.

1863. *Chilo incertulas* Walker, Cat. Het. XXVII, p. 143(♂).
1863. *Catagela(?)admotella* Wlk. Cat. Het. XXVII, p. 192(♂).
1863. *Tipanoea bipunctifera* Wlk., Cat. Het. XXVIII, p. 523(♀).
1863. *Chilo gratiosellus* Wlk., Cat. Het. XXX, p. 967(♀).
1863. *Schoenobius punctellus* Zeller, Chil. et Cramb. p. 4(♀).
1863. *Schoenobius minutellus* Zell., Chil. et Cramb. p. 5(♂).
1896. *Schoenobius bipunctifer* Hampson, Faun. Brit. India, Lepid., vol. iv, p. 48(♀), fig.
1896. *Schoenobius incertellus* Hamp., Faun. Brit. India, Lepid., vol. iv, p. 48(♂).

The original descriptions of *Chilo incertulas* (male) and *Tipanoea bipunctifera* (female) by Walker are as follows:

"**Mas.** Pallidissime cervinus; alae anticae fusco conspersae. puncto discali punctisque marginalibus nigris, linea exteriore strigulis diffusis nigricantibus; posticae albidae."

"**Fem.** (Mas. Walker in error). Albida; alae anticae ochraceo pallidissimo subtinctae; gutta discali exteriore nigra elongata."

### A. Japanese Names.

Dr. Yoshinari Otsuka in 1885 designated the larva of this insect as "Sanka-Meichyu." The imago of the paddy Pyralid has since been



named as "Sanka-Meichyu-Ga". The species has been recorded, in 1905, by Prof. S. Matsumura in his Catalogue Insectorum Japonicum under the name of "Itten-O-Meiga". The name "Sanka-Meichyu" or "Sanka-Meichyu-Ga" first originated from the nature of the insect, which has three generations in a year. It was afterwards found that this insect has from four to six generations a year in Formosa, and two or three in Japan, therefore the name "Sanka-Meichyu-Ga" is not appropriate, and "Itten-O-Meiga" seems the more suitable.

### B. Local Names.

Owing to the fact the borer occurs in most parts of the eastern hemisphere, it has become known under various local name. In Formosa it is very generally known as "YAA" or "TSUWYAA", and since 1907 "Itten-O-Meichyu". In Japan is known under the following names:— Zuimushi; Sashi-Mushi; Shin-Mushi; Ho-Mushi; Sudoshi; Su-Mushi; Do-Mushi; Ho-Gare-Mushi; Ne-Mushi.

All the above names are invariably confused with two other paddy borers, *Chilo simplex* Butl. and *Nonagria inferens* Wlk. In Burma and the Philippines our "Itten-O-Meichyu" is known as the "Paddy Pyralid"; in Java as the "Paddi Boorder"; in India as the Paddy Stem-Borer".

These names have the same meaning, and throughout this bulletin the name "Itten-O-Meiga" is adopted.

## Chapter II.

## Geographical Distribution.

Few, if any, species of insects injurious to the rice plant are more widely distributed, than is our "Itten-O-Meiga". Within about 75 and 135 east longitude, and about 10 south, and about 35 north latitude, the localities of its occurrence from an almost complete rectangle. In its vertical distribution it is known to occur at sea-level at many

places, and it has been collected from Hakku in Nanto, Formosa, by Mr. Asakura at altitude of 5000 feet. In Ceylon, it occurs from sea level to 2000 feet in the Kandy district.

In the accompanying map of the east hemisphere the principal points of its occurrence are indicated by dots. In Formosa it occurs practically everywhere, but not higher than 5000 feet above sea-level. The map is based on information gathered from different sources, but principally from the labels of specimens in the British Museum, and from letters recieved from foreign governments.

The following classified list will indicate more exactly the localities where the species is known to occur :—

Japan :— Sanin-Do; Sanyo-Do; Nankai-Do; Saikai-Do; Riukiu Is.
Formosa :— Nearly throughout the island.
China :— Fu-Kien; Kiang-Su; Kwang-Tung; Kwang-Si; Hainan Id.
India :— Nearly throughout the southern part; Cassia Id.
Burma :— Thayetmyo; Rangoon; Tenasserim; As
Cambodia :— Pnom-Peuh.
Malay Peninsula ;— Penang; Singapore.
Tongking :— Hanoi.
Annan :— Hue.
Siam :— Bankok.
Ceylon :— Colombo; Kandy; Trincomalee; Maskeliya.
Sumatra :— Deli.
Java :— Batavia; Surabaya; Samarang.
Borneo :— Kuching; Bintulu; Sandakan.
Cochin China :— Saigon.
Philippine Is. :— Manila; Taytai; Mindanao.

In Japan, it has been recorded by Mr. Hisatomo Nakagawa, that it occurs as far north as 37°7′, and as regards in its vertical distribution it is often confind to low-lying areas, while absent from the neighbouring high and mountainous lands :—

Shikoku :— Iyo (Kami-Ukiana); Tosa (Kami; Nagaoka; Tosa;



and Wagawa counties).
Kiushiu :— Bungo (Kusu and Naoiri counties); Higo (Kuma county)

The general conclusion formed is that this insect occurs widely in lowland districts where rice plant is cultivated, while it is absent from the highland cultivated areas, and apparently does not attack the wild plants.

## Chapter III.

### Original Home.

In the case of injurious insects it is important to determine if possible, the actual locality where they are indigenous and from which they have spread to other countries. Many of the most injurious insects have been introduced from foreign countries, becoming elsewhere much greater pests than in their native homes. This result is due in part, at least, to the fact that at the same time their parasitic and predaceous enemies have not been introduced with them, and they are thus able to develop freely unmolested by these important checks. It is however an undoubted fact that other species, occurring in the new locality, begin gradually to attack the introduced insect, and that the number of powerful enemies increases every year.

I have recieved many notes concerning the injuries of "Itten-O-Meiga" to the rice plant from entomologists and agriculturists in many countries where this insect occurs. In Ceylon, the injury seems to be less than in other countries, and I hear from Mr. E. E. Green that "Itten-O-Meiga" is sometimes taken by collectors, but it seems never to have been known as an injurious insect to the rice plant until now. Elsewhere, it is known that "Itten-O-Meiga" is one of the most terrible pests of the paddy, and that the rice fields are very often damaged at the rate of about 20-50 per cent by this borer.

I have drawn the following conclusions from the facts mentioned

above :—

(1). In Ceylon, "Itten-O-Meiga" is p ·bly not confined to rice plant, and consequently may not do great damage, although feeding paddy.

(2). In other countries, it is a serious pest of the rice plant; and being perhaps introduced, there are probably no powerful enemies.

(3). In Ceylon, atmospheric conditions may possibly be unfavorable to the increase of "Itten-O-Meiga"; or the natural enemies may be numerous and powerful.

(4). In othor countries, atmospheric conditions may possibly be favorable to the increase of the insect, though it may meet with many enemies.

At the present time it is very difficult to determine the original home of the insect, because there are many enemies in the countries in which it occurs and it seems that th balance of nature is well maintained between "Itten-O-Meiga" a ts enemies, but from the facts mentioned I shauld infer that the original home may be Ceylon.

## Chapter IV.

## Food plants.

Few, if any, species of insects are more restricted with regard to food plants than is "Itten-O-Meiga". Throughout its range, the paddy is the only plant known to furnish subsistence to this insect, with the single exception; that in Burma, according to Mr. R. D. Schroff, it has been noted as feeding on the rice plant, wheat and grasses.

Mr. E. E. Green, for many years Government Entomolegist in Ceylon, says that its food plant in Ceylon is still unknown, while according to observations by Mr. L. Lewton-Brain, in Siam, Mr. T. B. Fletcher in India, Mr. F. W. Taylor in the Philippines and Dr. J. C. Konigsberger in Java, its only food plant is the rice, and this is



also the case in Japan as proved by investigations carried out for many years at several Japanese Agricultural Experiment Stations.

My own investigations in Formosa, extending over five years, also led to the conclusion that in that island "Itten-O-Meiga" is also confined exclusively to the rice plant. I selected for special observation several gramineous plants which grow commonly in fields and mountainous districts in Formosa, thinking that although it was obvious that "Itten-O-Meiga" preferred the rice plant it was possible it might also feed on other gramineous plants. I most carefully searched these plants to ascertain whether the larvae (or pupae) of "Itten-O-Meiga" ever occurred in the stems, but in no single instance did I meet with the larva of this species, as the following table shows :—

**Table I.** Investigation of various plants in Formosa.

| Locality | Date | Name of plants examined | Number of stems examined | Number of insects living in the stem | | |
|---|---|---|---|---|---|---|
| | | | | Schoen. incert-ellus | Chilo simplex | Nonag. inferens |
| Taihoku, northern part of Formosa. | Each month. 1909 | Miscanthus sinensis. | 1135 | 0 | 15 | 19 |
| | | Zizania latifolia. | 622 | 0 | 17# 55 | 13 |
| | | Sugar Cane. | 610 | 0 | 0 | 14 |
| | | Panicum proliferum. | 1200 | 0 | 0 | 0 |
| | | Teosinte. | 450 | 0 | 0 | 1# 32 |
| | Each month. 1910 | Miscanthus sinensis. | 1100 | 0 | 0 | 15 1# |
| | | Zizania latifolia. | 1087 | 0 | 7# 10 | 4# 10 |
| | | Panicum proliferum. | 600 | 0 | 0 | 0 |
| | | Teosinte, | 100 | 0 | 0 | 0 |
| | Each month. 1911 | Miscanthus sinensis. | 1200 | 0 | 1# | 18# |
| | | Zizania latifolia. | 1176 | 0 | 2# 3 | 14 |
| | | Teosinte. | 100 | 0 | 0 | 0 |
| | | Barley. | 100 | 0 | 0 | 14 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Taichiu, middle part of Formosa. | Each month. 1909 | Zizania latifolia. | 429 | 0 | 0 | 0 |
| | | Miscanthus sinensis. | 1840 | 0 | 0 | 16 |
| | | Imperata arundnacea var. | 628 | 0 | 0 | 0 |
| | | Erianthus sp. | 200 | 0 | 0 | 1# |
| | | Eragrostis major. | 133 | 0 | 0 | 1 |
| | | Several gramineous plants. | 1763 | 0 | 0 | 0 |
| | Each month. 1910 | Zizania latifolia. | 418 | 0 | 5 | 2 |
| | | Miscanthus sinensis. | 1899 | 0 | 0 | 1# |
| | | Imperata arundnacea var. | 120 | 0 | 0 | 0 |
| | Each month. 1911 | Eragrostis major. | 3114 | 0 | 0 | 19 |
| | | Imperata arundnacea var. | 50 | 0 | 0 | 0 |
| | | Zizania latifolia. | 137 | 0 | 0 | 0 |
| | | Sugar Cane, | 10 | 0 | 0 | 6 |
| Hozan, southern part of Formosa. | Each month. 1909 | Miscanthus sinensis. | 800 | 0 | 0 | 2 |
| | | Ischaemum rugosum var. | 700 | | 2 | 2# 8 |
| | | Paspalum scrobiculatum. | 250 | | 0 | 6 |
| | | Calamagrostis epigejos var. | 550 | | 0 | 3 |
| | | Scirpus mucronatus. | 150 | 0 | 0 | 0 |
| | | Scirpus lacustris. | 100 | 0 | 0 | 10 |
| | | ? | 50 | 0 | 0 | 0 |
| | Each month. 1910 | Ischaemum rugosum var. | 290 | 0 | 5 | 9 |
| | | Paspalum scrobiculatum. | 250 | 0 | 0 | 5 |
| | | Miscanthus sinensis. | 342 | 0 | 0 | 5# 23 |
| | | Calamagrostis epigejos var. | 150 | 0 | 0 | 0 |
| | | Phragmites communics. | 31 | 0 | 0 | 0 |
| | | Panicum repens. | 30 | 0 | 0 | 0 |
| | | Scirpus lacustris. | 75 | 0 | 0 | 1# |
| | | Scirpus mucronatus. | 473 | 0 | 0 | 0 |
| | Each month. 1911 | Miscanthus sinensis. | 420 | 0 | 0 | 3# 11 |
| | | Ischaemum rugosum var. | 195 | 0 | 0 | 0 |
| | | Paspalum scrobiculatum. | 206 | 0 | 0 | 1 |
| | | Calamagrostis epigejos var. | 216 | 0 | 0 | 0 |
| | | Phragmites communics. | 40 | 0 | 0 | 0 |
| | | Scirpus mucronatus. | 40 | 0 | 0 | 0 |

Note : " # "..... pupa ; " without mark "..... larva.



On splitting the stems in addition to the species mentioned in the table I found larvae of many other species of *Lepidoptera*, e. g., those of *Eucosma schistaceana* Snell., *Diatraea striatalis* Snell., *Chilo infuscatellus* Snell., etc. I also found one larva allied to "Itten-O-Meiga" among these, and reared it; but it proved to belong another species of *Schoenobiinae*. I attempted to rear "Itten-O-Meiga" on several gramineous plants, by introducing the eggs and the larvae into the stems, but without success, thus confirming the general opinion that the species feeds only on the rice plant.

## Chapter V.

## "Itten-O-Meiga" in Other Countries.

Throughout its extended range, the actual injury to the rice plant occassioned by "Itten-O-Meiga" has been nowhere so carefully observed as in Japan and Formosa. Although undoubtedly the amount of loss sustained in other countries is not inconsiderable, and it is very necessary that records showing the actual amount of damage to the rice crop, in countries other than our own, should be ascertained.

In the provinces of Kwang-Si and Kwang-Tung in China the insect is very generally distributed, and it is apparently very destructive in some parts, but usually the damage is not so great as in Formosa. I do not know the actual conditions in other provinces of China.

Mr. K. D. Schroff writes that "Itten-O-Meiga" was observed by him injuring rice plants, wheat and other gramineous plants in Burma, and that it is very destructive to the rice plants, but he did not investigate the percentage of damage.

In Ceylon, Mr. E. E. Green writes that "Itten-O-Meiga" is not to attacks the rice plant, and what is its food plant there is still unknown.

In the Malay Islands, according to Mr. L. Lewten-Brain, this pest does not usually occasion much damage, but in a few particular

years it has been very destructive.

Mr. F. W. Taylor writes that "Itten-O-Meiga" is one of the most serious pests of the paddy in the Philippines, and Dr. J. C. Konigsberger writes that it is a serious pest in Java, while in the southern parts of India Mr. T. B. Fletcher has noted the injuries caused, as generally, somewhat considerable.

## Chapter VI.

## "Itten-O-Meiga" in Japan and Formosa.

### A. In Japan.

In Japan, the amount of injury to the rice pla which should be attributed to "Itten-O-Meiga", undoubtedly var yearly, and is difficult to estimate with any degree of certainty, and we have no really reliable records as to the actual damage done in ancient times.

Mr. Sohei Masuda, Mr. Hisatomo Nakagawa and Dr. Y. Otsuka have published the following records, which they mainly obtained from the traditions of old farmers, living in Kiu-Shiu, Sanin and Sanyo, which are probably more or less reliable.

In Kiu-Shiu:— "White ears" (Shira-Ho) of rice plant characteristic of attack by "Itten-O-Meiga" have been observed for about 130 years in Saga-Gun (Saga-Ken); in Yatsushiro-Gun and Udo-Gun (Kumamoto-Ken), for about 140 years; in Taniyama-Gun (Kagoshima-Ken), for at least 100 years; and in Yame-Gun and Mito-Gun (Fukuoka-Ken), for about 140 years.

The percentage of crop destroyed in these districts varied greatly in different years. Out of every ten years the average might be about 50% to 60% for four or five years, and about 20% to 40% during the remaining five or six years. In some districts, it became necessary to reduce the land tax, owing to the serious damage done, and some farmers were even obliged to leave their dearly loved homes and to settle in other localities.



Such records indicate that there have probably been serious outbreaks of "Itten-O-Meiga" during the last 150 years, perhaps, also, associated with attacks by *Chilo simplex*, and it would seem that the damage may even have been greater than it is in our own time.

In Shikoku:— "White ears" have been observed for about 65 years in Koshichi-Gun (Yehime-Ken) and much damage was done, possibly more than 40% of the crop being destroyed. In Sakuragi-Mura, Nakagawa-Mura, Tano-Mura and Ishine-Mura (Shiusho-Gun), where there is much standing water and a clay soil, "white ears" have occurred from still earlier times.

Here we have an indication of probable outbreaks of the pest in Shikoku from about 50 to 60 years ago, and the injury was perhaps greater than it is now. At the present time "Itten-O-Meiga" is most destructive to the rice plant in Fukuoka-Ken and Saga-Ken, and the injury amounts annually to about 20% of the crop. In other prefectures it varies from about 1% to 20%.

### B. In Formosa.

#### I. Early times.

Nothing has been recorded about the early occurrence of "Itten-O-Meiga" in Formosa, I have therefore endeavoured to ascertain anything that was known by tradition to old farmers and others interested in agriculture, and the result of my enquiries may be classified as follow:—

#### (1). Nanto-Cho.

#### (a). Nanto prefectural district.

It is not known when the "white ears" first appeared, possibly they may have been noticed when the careful cultivation of rice began, whether the amount of damage done was serious is unknown, but coming to recent times, during the year 1904, 50% of the crop was destroyed.

The cause of the production of the "white ears" was overlooked, but vulgar tradition attributing their occurrence to the influence to a warm South-West wind, or to a continuous gloomy and drizzly weather throughout the flowering period.

**(b). Rinkiho prefectural district.**

The "white ears" have been noticed for a good many years, how many years is uncertain, they have however appeared in large numbers since the year 1886, but the injury was not excessive until the year 1910, when the damage done was very serious.

The traditions I met with concerning the cause and origin of the "white ears", are as follows :—

Their appearance on the first crop is attributed showery or changeable weather during the shooting period ; or on the other hand it is suggested that it might be dependent on the innumerable and unseen influenses of gods, demi-gods and devils, or even on the ill-doings of one of the inhabitants, or it might be caused by political or local changes such as the appointment of a new governor.

**(c). Soaton prefectural district.**

Again we have no actual information as to when the "white ears" first appeared, but it would seem that before the year 1903 the annual percentage of the crop destroyed was about 0. 2% or 0. 3% on the first crop, and about 0. 1% on the second crop. Since the year 1903 the percentage damage to the crop appears to have been gradually increasing, from about 0. 4% to 0. 6% on the first crop, and from about 2% to 3% on the second. This may be partly influenced by other plants which are cultivated to serve as a green manure.

The "white ears" were observed to be very abundant whenever paddy was transplanted late in the season, and especially when there was excessive rain, but the "white ears" were less frequent when the rice plant was transplanted early and there was continuous fine weather.

**(d). Shiushiu prefectural district.**



There are many traditions concerning the date of the first appearance of the "white ears" in this district, they will probably first noticed about the year 1800, but the damage appears to have been slight, and might be variously estimated at from 1 to 4 per cent on both crops.

The cause for the production of the "white ears" are supposed to be as follows :—

They occur plentifully whenever there is continual rain during the flowering period, but it is suggested that if it is not raining from 10 a. m. to midday they are less plentiful. A continuous South-West wind during the flowering period is said to be the cause of the "white ears", and the "Hoi-Sho-Fou" (a hot blast) blowing from the east during the same period is believed to produce the same effect.

**(e). Horisha prefectural district.**

Although the "white ears" are said to have been noticed by farmers in this district so far back as the year 1854, we do not seem to have any really reliable evidence as to the occurrence of "Itten-O-Meiga" until about the year 1891 when the percentage of the crop destroyed was from 3% to 5%.

Tradition attributes the production of the "white ears" to the following causes :—

"White ears" are said to be caused by incessant rain, or by frequent and sudden changes of wheather, and by sudden cold rain during hot weather, especially during the flowering period. Superstition attributes "white ears" to the vengeance of Heaven occasioned by the evil deeds of one or more of the farmers, and in such cases the gods and goddesses must be propitiated to remove the scourge of the "white ears". It is even thought by some of the farmers, that the visit of a great nobleman to a rice district, when the paddy is in flower, may occasion an attack of "white ears" for the god or wealth, virtue and justice, who is

also supervisor of the crops, cannot give his undivided attention to the inspection of fields, when part of his time is occupied in escorting the nobleman through the district!

The date of the first appearance of the "white ears" in Nanto-Cho is not known with certainty, it probably coincided with the introduction of rice culture··· in some localities perhaps 100 years ago in others perhaps so recently as during the last 15 years, and the damage done was probably not very great.

It is the general belief of the husbandmen throughout Nanto-Cho that occurrence of the "white ears" is attributable to the weather, or to the unseen influence of gods, demi-gods or devils.

### (2). Tainan-Cho.

#### (a). Akoten prefectural district.

The "white ears" have been found in this district for many years, and the annual percentage of loss appears to be about 10%.

According to local tradition, the "white ears" are produced in seasons when a North or South wind blows before the rice plant bears seeds.

#### (b). Kanteibio prefectural district.

The "white ears" have been known to occur in this district for at least about 300 years ago, and the annual percentage of loss has varied from about 10% to 20%.

In this district tradition attributed the occurrence of "white ears" to North, East, or South winds blowing continuously, especially during the shooting period when certain kinds of paddy are most liable to injury. Unsettled weather throughout the shooting period, or changeable weather during the day, (e. g., showery in the morning and fine in the afternoon), is said to cause "white ears". There is also a general impression that if the irrigation water is too warm or too deep "white ears" will result.



#### (c). Hozan prefectural district.

The "white ears" have occurred in this district since the time when paddy was first cultivated, but in some districts they have only been observed during the last 40 years··· the percentage has varied from about 20% to 50%.

In this district, it is generally believed that "white ears" appear on the first crop whenever the North wind blows causing the temperature to drop suddenly; and on the second crop when the wind blows from the South and the temperature suddenly rises; excessive rain during the shooting period or lack of sunshine and absence of dew, before or during the shooting period.

#### (d). Takao prefectural district.

The "white ears" have been known here for a very long time and their percentage has varied from about 20% to 50%.

Here again tradition attributes the occurrence of "white ears" on the first crop, to a prevailing North wind, and on the second crop to warm weather occasioned by winds from South.

#### (e). Shoro prefectural district.

Contemporary records of the occurrence of "white ears" in the Shoro district so far back as the year 1680 still exist in manuscripts, but these records do not give us any idea of the actual damage caused by the pest. In this district, it is thought that "white ears" appear in seasons when there is an absence of fine weather and South winds blow, or after a heavy drought.

#### (f). Tainan prefectural district.

The "white ears" have been found here for probably more than a hundred years and the injury has probably varied from 6% to 10%.

The causes of the production of the "white ears" are handed down by tradition as follows:—

> The farmers in this district are of opinion that "white ears" appear after North winds laden with sea-moisture have blown over the first crop before or during the shooting period, and that

the South wind produces the "white ears" on the second crop, in September, they also think that very changeable weather produces the same effect on either crop during the shooting period.

**(g). Taimokko prefectural district.**

Here again the "white ears" have been known for about a century, and the injury probably varied from one fifth to one third of the present annual loss.

In this district, the "white ears" are thought to be caused by the North wind blowing frequently over the first crop, and the South wind over the second crop; cold winds during hot weather are thought to produce them, and they are also believed to be caused by the sound of the angry waves beating loudly on the shore!

As regards the whole province of Tainan-Cho, although the "white ears" have been to occur in some district since 1653, they have not been noticed in others until as late as 1883…the percentage has probably varied from about 5% to 50%. It is the belief of the farmers that the appearance or non-appearance of the "white ears" depends mainly on the weather.

**(3). Shinchiku-Cho.**

**(a). Shinchiku prefectural district.**

The "white ears" were first found here about 130 years ago, and the annual percentage has varied from 2% to 3%, but is now slightly higher… the non-glutinous crops appear to be less affected than the glutinous.

According to tradition in this district "white ears" are believed to be caused by winds from the South.

**(b). Shimpo prefectural district.**

The "white ears" have been observed in the coast district for about 300 years, and inland for about 140 years. The injury has



probably amounted to about 3%, and again the glutinous crops have suffered more than the non-glutinous.

The "white ears" are thought to be caused by after drought, or by prevailing South winds before the shooting period.

**(c). Jukirin prefectural district.**

The "white ears" have been known to occur for many years… the average loss has probably varied from 5% to 15%, but in the year 1882 they appeared in great numbers and the percentage was much higher.

It is considered in this district that "white ears" are caused by continuous South winds during the shooting period, and if this wind should blow at "Hakuro"# it is believed the injury to the second crop would be much more serious.

**(d). Hoppo prefectural district.**

The "white ears" have only been found here since 1890, and the percentage in low-lying fields has been from 10% to 15%, and in mountainous fields even less.

The "white ears" are said to occur when a South wind blows continually before and after "Hakuro."#

**(c). Nansho prefectural district.**

The "white ears" have been noticed since 1863 (some persons think as early as 1852); the percentage has been estimated at from 7% to 8% annually, but in 1887 the injury was very serious, amounting perhaps to 70%.

In Nansho district "white ears" are thought to be caused by strong sunshine after a shower, or by cold rain while the sun is shining, and also by South winds blowing continually.

**(f). Tofun prefectural district.**

About 10% of "white ears" have been found in this district since

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# "Hakuro" is a day in Autumn in the Lunar calendar, and coincides with 8th. September in the Solar calendar.

about 1832 (or 1843), but in 1883 they were not found at all, while in 1887 there was a sudden increase the percentage of injury reaching as high as 70%.

In Tofun district "white ears" are said to appear after continuous winds, also after strong sunshine following a shower, or after cold rain while the sun is shining; rain in the morning from 11 till midday is also thought to be the cause of "white ears".

**(g). Bioritsu prefectural district.**

The "white ears" have been found as long as rice has been cultivated in this district, but the annual loss has been small amounting only to about 1. 5%.

The "white ears" are said to be caused by the wind.

**(h). Taiko prefectural district.**

The "white ears" have occurred in this district from early times, but the annual percntage has been small, on an average about 2%.

The "white ears" are thought to be caused by South winds blowing before or during the shooting period, or by continuous sultry weather after a shower.

**(i). Sansaho prefectural district.**

Although "white ears" have been found in this district from early times, the percentage has only averaged about 1. 5%.

The causes for the production of the "white ears" are handed down by tradition as follows:—

The "white ears" are said to appear after continuous South winds before or during the shooting period, or after sultry weather following a shower, and also to be caused by water remaining between the sheaths and becoming stagnant.

**(j). Tsuwsho prefectural district.**

The "white ears" have been found here for about 60 or 70 years, but the annual loss has only been from 1% to 5%.

The ocourrence is attributed to some unknown natural cause.



The "white ears" first appeared in the province of Shinchiku-Cho, about 200 years ago when paddy cultivation began, but in some districts they have not been known to occur for more than 60 or 70 years ... the annual loss appears to have been from 1% to 15%.

It is the general belief of the farmers that the abundance or scarcity of the "white ears" is mainly dependent on the weather.

**(4). Taichiu-Cho.**

**(a). Taichiu prefectural district.**

The "white ears" have been known here for about 100 years, and the annual percentage has ranged from 2% to 5%, and their occurrence is accounted for South winds accompanied by heavy rains, and especially if water is retained between the sheaths of paddy; also in such fields as are too much enclosed by trees, etc.

**(b). Inrin prefectural district.**

The "white ears" have occurred for about eighty years ago, and the percentage has been about 4% or 5%.

The "white ears" are thought to appear after strong South winds, or after very changeable weather.

**(c). Toseikaku prefectural district.**

The "white ears" have been known to the farmers in this district for about 50 years, and the annual loss has varied from 2% to 7%.

South winds accompanied by thunder and rain are believed to produce them.

**(d). Koroton prefectural district.**

From 2% to 5% is estimated to be the damage caused annually by the "white ears" in Koroton district during the last 70 years.

South winds with rain are believed to cause them.

**(e). Hokuto prefectural district.**

The "white ears" have been found for at least a hundred years, and the percentage has varied from 2% to 5%.

The farmers think they appear on the paddy after South winds, or when base of the stem of the plant has become rotten.

**(f). Jirin prefectural district.**

The "white ears" have been known in Jirin district for about 170 years, but their annual percentage has not been serious, only about 2% to 4%.

They are thought to accur after strong South winds.

**(g). Shoka prefectural district.**

The "white ears" have only been noticed here during the last 50 years; it is not thought that the annual loss has been more than 2% to 5%.

The white ears" are believed to appear after South winds accompanied by thunder and rain, especially if after heavy rains the rice plants remain standing in stagnant water.

**(h). Sharoku prefectural district.**

When the "white ears" first appeared in Sharoku district does not appear to have been noted by the farmers, it is, however, certain that they have occurred for at least 23 years, the loss varying from 2% to 5%.

Their appearance is thought to follow South winds with thunder and rain.

**(i). Taiko prefectural district.**

The "white ears" have damaged the paddy crops in Taiko district for about 100 years, but perhaps only from 2% to 5% annually.

Changeable weather, or South winds accompanied by thunder and rain at sunset are believed to produce the "white ears" in this district.

**(j). Rokko prefectural district.**

The "white ears" have been known here about a century, the annual loss varying from 2% to 5%. They are said to appear after strong South winds.



The earliest date of the appearance of the "white ears" in the province of Taichiu was probably about 160 years ago, although in some districts they have perhaps not been observed for more than 60 years. This is rather later than the date when rice cultivation began in the districts of Taichiu-Cho (about 230 years ago).

It is the belief of the farmers that the occurrence of the "white ears" depends mainly on the weather, but they do not seem to have occasioned much loss annually, probably from 2% to 5%.

**(5). Giran-Cho.**

The "white ears" were apparently first observed in the province of Giran-Cho 27 years ago, and the yearly loss varied from 3% to 4% of the first crop; in the years 1885 and 1910 the loss was even less (1. 2% to 2% in different districts).

The "white ears" are said to appear whenever the irrigation water becomes stagnant through of bad drainage before the shooting period, or when the heat of the sun has been excessive during the shooting period; or if a strong South wind blows for three days during the shooting period, or there is frequent rain.

The actual date when the "white ears" first appeared in the province of Giran-Cho is not known with certainty, but "Itten-O-Meiga" has probably only been introduced within the last few years, and so far has done little damage.

**(6). Kagi-Cho.**

**(a). Kagi prefectural district.**

The "white ears" have been known here about 50 years, until about 20 years ago the annual percentage was only about 5% to 10%, but since then it has risen to from 10% to 20% annually.

The Kagi farmers think that the "white ears" appear after strong North winds blowing over the first crop, and after South winds

blowing over the second crop.

**(b). Chiuho prefectural district.**

The "white ears" have occurred about 60 years, the annual percentage varying from 5% to 10%.

The "white ears" are said to appear on the first crop after North winds during the shooting period, and on the second crop after strong South winds.

**(c). Chikutoki prefectural district.**

During the 40 years, or more, the farmers have known the "white ears" in this district; the annual loss has been estimated at 4% or 5%.

North winds blowing over the first crop, and South winds blowing over the second crop are thought by the natives to cause the "white ears".

**(d). Dabio prefectural district.**

The "white ears" were probably first noticed in Dabio district at least 60 years ago and have occasioned an annual loss of from 1.5% to 2%.

Here again North winds blowing strongly over the first crop, and South winds over the second crop are believed to cause the "white ears", and also sudden rain during strong sunshine chilling the paddy in the shooting period.

**(e). Toroku prefectural district.**

The "white ears" have been known here for a long while and the percentage has varied from 3% to 10% annually.

South winds, or rain following by bright sunshine, during the shooting period are considered to produce the "white ears" in this district.

**(f) Toko prefectural district.**

The "white ears" have been observed in Toko district about 40 or 50 years, and about 5% to 10% of the crop has been affected.

The "white ears" are thought to appear after strong North



winds during the first crop, ½ South winds during the second crop.

**(g). Seira prefectural district.**

In this district rice cultivation began at least 250 years ago, and the "white ears" probably became more numerous as rice cultivation increased. The annual percentage was usually 2% or 3%, but occasionally amounted to 10%. The "white ears" are thought to be caused by the South winds.

**(h). Yensuiko prefectural district.**

The "white ears" have occurred here 50 or 60 years ago and their percentage has amounted to 10% or 20% of the crop.

The "white ears" are held to appear when North winds have blown over the first crop, or South winds over the second crop; changeable weather during the shooting period is also thought to occasion them.

**(i). Tenshiko prefectural district.**

Although the "white ears" have been known to the rice-farmers in this district for many years, they have not caused serious loss till about 23 years ago when the annual percentage rose to about 10%, and has even sometimes been as high as 50%.

The "white ears" are said to appear in Tenshiko district after North winds blowing over the first crop, and after South winds blowing over the second crop; in some districts they are thought to be caused by the South winds blowing during "Hakuro", while on the other hand they are very scarce when the North winds blow during "Kanro"#.

The "white ears" have been known to occur in the province of Kagi-Cho for about 250 years, they were probably first noticed about 12 or 13 years after rice cultivation began, and the annual percentage has probably varied from 2% to 10%.

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# "Kanro" a day of Autumn in the Lunar calendar, coinciding with 8th. October in the Solar calendar.

The general belief of the Kagi-Cho farmers is that the "white ears" are caused by the wind.

### (7). Daito-Cho and Karenko-Cho.

Rice has been cultivated in parts of these provinces for at least 60 years, while in other districts the cultivation of paddy has only been seriously undertaken during the last 20 years. In the older rice districts the "white ears" have been known for 50 years, but on newer rice-lands for only 14 or 15 years. They have apparently occasioned little damage to the crops since the percentage is only estimated at from 0. 5% to 1%.

The "white ears" are believed by the farmers of these provinces to be caused by changeable weathar, or strong winds.

### (8). Taihoku-Cho.

#### (a). Pankio prefectural district.

Although paddy has been cultivated by the farmers in this district for many years, the actual date, when the "white ears" first appeared, is unknown; in recent years the annual percentage has been 2% or 3%.

The "white ears" are said to appear after a strong South-West wind during the shooting period.

#### (b). Shinsho prefectural district.

The "white ears" have been known here for about 50 or 60 years, the percentage varying annually from 3% to 4%, but occasionally rising as high as 10%.

In Shinsho district the "white ears" are believed to appear after a South wind has continued for 4 or 5 days, or if there is frequent rain, or a strong South-West wind during "Hakuro"; they are also said to be produced by two much manure or bad ventilation.

#### (c). Shirin prefectural district.

The "white ears" have occurred here for about 40 or 50 years,



and the percentage has gener. · been about 5%, but some years has risen to as much as 10%

The "White ears" are believed to be occasioned by continued South-West winds during the shooting period.

#### (d). Shakko prefectural district.

For many years the "white ears" have occasioned an annual loss of about 5% in the district of Shakko, appearing it is believed after changeable weather or when South-West winds prevail, on the other hand they are quite scarce after easterly winds.

#### (e). Suihenkiaku prefectural district.

The "white ears" have been known in this district about 70 years, but have done little damage to the crop ··· only about 0.5% or 0. 6%. The first crop appears to suffer most injury when North-West winds blow suddenly after close weather, or after prevailing West winds during the shooting period, while they are most noticeable on the second crop after frequent South-West winds and cold weather.

#### (f). Tamsui prefectural district.

It is not known how long the "white ears" have occurred in Tamsui district, but during recent times the percentage has been from 2% to 3% annually.

Windy or rainy weather are thought to cause the "white ears".

#### (g). Shokiirun prefectural district.

In this district the "white ears" have reduced the crop annually by about 5% for many years.

The "white ears" are said by the farmers to appear, after Southwinds, or whenever a "white-rainbow"# has appeared at night, or as a punishment for evil deeds done by one of the Shokiirun farmers

#### (h). Kimpori prefectural district.

The "white ears" have shown an annual injury of about 5% to the Kimpori paddy crops during the 30 or 40 years.

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# "Hakko" (white-rainbow) is a strange light of rainbow-like appearance in the sky. It is not known among Japanese people

The "white ears" have been noticed most frequently after South winds during the shooting period, or after frequent rains and thunder storms, and especially if rainbows have been often seen.

**(i). Kiirun prefectural district.**

Although the "white ears" have probably occurred here for many years, they have been actually observed for about 17 years... the percentage has been generally from 5% to 6%, but in some years has amounted to as much as 10%.

Frequent North or South winds during the shooting period are thought to cause "white ears"

**(j). Zuiho prefectural district.**

The "white ears" have only been actually observed in Zuiho district during the last 10 years, although they have probably occurred for a good many years ··· the annually injury to the crop has been estimated at from 5% to 10%.

Rainy and windy weather during the shooting period are thought to produce the "white ears".

**(k). Chosokei prefectural district.**

The "white ears" have been known to the farmers of Chosokei for about 21 years and the annual percentage has been generally about 10%, but occasionally about 20%.

The "white ears" appear when North winds blow on the earlier crop, or West winds on the later crop immediately before the shooting period; excessive heat during the same period is also believed to be another cause.

**(l). Shinko prefectural district.**

The "white ears" have occurred here for many years and the annual percentage has been generally about 1%, but has sometimes risen to 5%.

Scarcity of rain and high temperature, or the use of too much fresh manure are thought to produce the "white ears".

**(m). Shinten prefectural district.**



The "white ears" have been observed in Shinten district for about 8 or 9 years, but they are said to have occurred in the district for many years.

The percentage during the last few years has been 4% or 5% and excepting as much as 10%.

The "white ears" have been generally noticed on the second crop after hot weather in the morning followed by rain in the afternoon, and also after continuous South-West winds during the flowering period. The first crop is said to be affected by South winds accompanied by cold weather and continuous rain. This is especially the cause during the shooting period.

The "white ears" have probably occurred in the province of Taihoku since the rice cultivation commenced, that is for about 200 years, and they have been actually observed by the farmers for 30 or 40 years, during which time their percentage has probably been from 0. 4% to 0. 5% but has occasionally risen to 10%.

It is the general belief that the "white ears" are caused by unfavourable weather.

**(9). Toen-Cho.**

The "white ears" have only been noticed in this province during the last few years, with a loss to the crops of from 4% to 5%.

They are believed to be caused by windy weather.

The general facts concerning the occurrence of the "white ears" in past times in Formosa, have been obtained from farmers, who have cultivated the rice plant for generations, son succeeding father in the same holding and handing down its traditions. Some of these traditions should perhaps be accepted with some reserve for there will always have been a tendency to hand down the memory of execptionally bad seasons which may now be attributed to the attacks of "Itten-O-Meiga," while the failure of the crop may have been due to exceptionally bad weather, seriously injuring the paddy and

producing an effect somewhat similar to the "white ears" caused by *Schoenobius incertellus*, *Chilo simplex*, and *Nonagria inferens*.

From the various information that has been obtained it seems fair to infer that "white ears" occur everywhere in Formosa where paddy is cultivated, in some districts they having been known for very many years, in others only for a short time. It should not however be assumed that "Itten-O-Meiga" has recently been introduced into the districts which have no traditions of its occurrence, for the absence of such traditions may equally will be attributed to less careful cultivation and lack of observation on the part of the farmers.

It is probable that "Itten-O-Meiga" was introduced into Formosa in ancient times, probably from China, and that it has gradually spread over the whole island, the "white ears" becoming most numerous in districts where much rice has been cultivated for a long period.

The percentage of damaged rice varies greatly according to the locality. In the South the injury is generally greater than in the North, and in the West than in the East, but it is probably increasing everywhere.

It is the belief of the farmers that the occurrence of the "white ears" depends chiefly on three factors:—

(I) the direction of the wind.

(II) the frequency or scarcity of rain.

(III) the punitive action on the part of gods or semi-gods.

The farmers believe bad weather to be the actual cause of "white ears", and it is possible that high temperature, and great humidity, may really be indirect causes by producing weather favourable to the increase of "Itten-O-Meiga" ··· the first two statements of farmers given above almost coincide as regards high temperature and extreme humidity. The belief that the injury to the crops is caused by the gods is probably associated with past attacks that have been so severe as to appear to the superstitions like a curse on the land.



## II. Recent times.

After carefully studying the amount of damage done to the rice plant in recent times, I find that *Schoenobius incertellus* is less injurious than is generally supposed, for although the ravages of "Itten-O-Meiga" are really very severe in some districts, in others many of the rice fields are quite free from the pest. In some districts the percentage of infested stems may average higher than 40%, as in the Hokuto prefectural district (Taichiu-Cho) during the year 1911, while in other districts it may fall as low as 0. 04%, as in the Seikoo prefectural district (Daito-Cho) during the three years (1910-1912). The actual annual percentage of infested stems (= "white ears") in the whole island of Formosa is probably 2. 72%, as shown by the average of the three years covered by my investigations (1910-1912).

During these years, I investigated the annual percentage of "white ears" in rice fields in each prefectural district. In each district three fields in different localities were chosen (one severely damaged, one moderately, and one only slightly), in each of these both the first and second crops were observed, and the total number of ears, and the actual number of "white ears" in a marked out plot twelve feet by six feet were counted separately in each locality, and the percentage of "white ears" in each locality ascertained. This percentage, however, is not actually true as regards "Itten-O-Meiga" as two other species of insects also produce the "white ears". The actual damage done to a rice plant by a single larva of either of the three species producing the "white ears" appears to be about the same, and the local rate of each of the three species remaining in the stubble is also about the same in both the crops.

The percentage of "white ears" occasioned by "Itten-O-Meiga" has been calculated in the following table from the observations alluded to above, using the formula:—

$$\frac{\frac{x' \times y}{100} + \frac{x'' \times y}{100}}{2} = x$$

x' = percentage of "white ears" on first crop.

x" = percentage of "white ears" on second crop.

$$y = \frac{100 \times a}{a + b}$$

a = number of larvae (and pupae) of "Itten-Meiga" remaining in the stubble on the second crop.

b = number of larvae (and pupae) of the two other species.

**Table II.** Percentage of "white ears" produced by "Itten-O-Meiga" in Formosa.

| Province | Prefectural district. | Percentage of "white ears" produced by "Itten-O-Meiga" | | | |
|---|---|---|---|---|---|
| | | 1910 | 1911 | 1912 | Average. |
| | | % | % | % | % |
| Ako-cho | Ako | 2.93 | 2.18 | 3.20 | 2.77 |
| | Toko | 0.86 | 0.56 | 1.80 | 1.08 |
| | Bozan | 0.68 | 1.84 | 1.50 | 1.34 |
| | Mansuw | 0.45 | 0.66 | 0.83 | 0.65 |
| | Banshorio | 2.79 | 2.31 | 4.21 | 3.10 |
| | Kosempo | 3.42 | 3.34 | 2.60 | 3.12 |
| | Choshiu | 1.99 | 1.51 | 1.00 | 1.50 |
| | Borio | 1.45 | 1.97 | 4.50 | 2.64 |
| | Koshun | 2.53 | 0.09 | 2.99 | 1.87 |
| | Ariko | 2.34 | 2.05 | 0.53 | 1.64 |
| | Rokkiri | .... | .... | 1.30 | 1.30 |
| | Average | 1.94 | 1.65 | 2.22 | 1.94 |
| Tainan-cho | Tainan | 1.82 | 5.83 | 8.38 | 5.34 |
| | Hozan | 3.56 | 8.77 | 7.73 | 6.02 |
| | Taimokko | 3.58 | 12.32 | 7.63 | 7.84 |
| | Kanteibio | 2.43 | 7.60 | 6.91 | 5 65 |
| | Tabanii | 2.03 | 6.37 | 4.17 | 4.19 |
| | Mato | 1.32 | 2.47 | 1.12 | 1.64 |
| | Rokko | 4.63 | 10.05 | 4.75 | 6.48 |
| | Takao | 3.95 | 5.27 | 9 43 | 6.22 |
| | Akoten | 3.20 | 7.57 | 3.57 | 4.78 |
| | Nanshiko | 1.20 | 8.17 | 5.59 | 4.99 |
| | Wanri | 0.49 | 1.03 | 1.01 | 0.84 |



| | | | | | |
|---|---|---|---|---|---|
| | Shoren | 1.30 | 7.23 | 5.52 | 4.70 |
| | Ampin | 0.0 | 7.04 | 3.06 | 3.39 |
| | Hokumonsho | ... | .... | ... | .... |
| | Average | 1.93 | 6.75 | 5.29 | 4.66 |
| Kagi-cho | Kagi | 7.52 | 7.13 | 6.96 | 7.20 |
| | Tenshiko | 5.08 | 2.75 | 0.77 | 2.87 |
| | Bokushikiaku | 1.45 | 0.38 | 1.09 | 0.97 |
| | Tosekko | .... | .... | 0.01 | 0.01 |
| | Dabio | 6.92 | 3.41 | 2.05 | 4.13 |
| | Teiko | 0.54 | 2.88 | 2.20 | 1.87 |
| | Seira | 4.60 | 5.90 | 8.10 | 6.20 |
| | Yensuiko | 0.78 | 1.37 | 0.08 | 0.74 |
| | Chiuho | 8.18 | 3.18 | 2.19 | 4.52 |
| | Hokko | 2.50 | 3.35 | 1.09 | 2.31 |
| | Kakoko | .... | .... | .... | .... |
| | Chikutoki | 1.68 | 2.83 | 0.90 | 1.80 |
| | Toroku | 2.42 | 2.85 | 2.53 | 2.60 |
| | Average | 3.82 | 3.27 | 2.33 | 3.14 |
| Nanto-cho | Nanto | 1.72 | 1.47 | 6.08 | 3.09 |
| | Shiushiu | 4.26 | 3.17 | 3.29 | 3.57 |
| | Soaton | 1.94 | 4.13 | 2.80 | 2.96 |
| | Rinkiho | 2.05 | 2.40 | 3.78 | 2.74 |
| | Horisha | 2.09 | 2.39 | 2.53 | 2.94 |
| | Average | 2.81 | 2.71 | 3.66 | 3.06 |
| Taichiu-cho | Taichiu | 6.21 | 8.01 | 16.51 | 10.24 |
| | Inrin | 0.58 | 5.74 | 24.26 | 1.19 |
| | Koroton | 1.62 | 6.36 | 6.25 | 4.74 |
| | Rokko | 1.35 | 7.01 | 1.49 | 3.28 |
| | Taiko | 1.83 | 4.24 | 2.49 | 2.86 |
| | Hokuto | 6.87 | 11.51 | 16.56 | 11.65 |
| | Shoka | 3.46 | 6.34 | 6.53 | 5.44 |
| | Toseikaku | 1.96 | 8.00 | 11.58 | 7.18 |
| | Sharoku | 0.08 | 2.85 | 8.54 | 3.82 |
| | Jirin | 0.32 | 5.65 | 3.37 | 3.11 |
| | Average | 2.43 | 6.57 | 9.86 | 6.39 |

| | | | | | |
|---|---|---|---|---|---|
| Sinchiku-cho | Shinchiku | 1.99 | 3.85 | 6.91 | 4.25 |
| | Taiko | 1.67 | 0.58 | 0.72 | 0.99 |
| | Bioritsu | 2 99 | 5.95 | 7.33 | 5.42 |
| | Nansho | 1.82 | 0.68 | 4.00 | 2.17 |
| | Jukirin | 6.18 | 6.59 | 2.42 | 5.06 |
| | Hoppo | 2.97 | 3.07 | 4.54 | 3.53 |
| | Sansaho | 4.95 | 1.93 | 1.52 | 2.80 |
| | Tsuwsho | 1.24 | 0.56 | 6.58 | 2.79 |
| | Koro | 0.15 | 3.67 | 1.16 | 1.66 |
| | Chiuko | 1.61 | 2.21 | 1.23 | 1.68 |
| | Shimpo | 0.70 | 1.68 | 4.32 | 2.23 |
| | Average | 2.39 | 0.97 | 3.70 | 2.35 |
| Toyen-cho | Toyen | 2.04 | 7.61 | 1.38 | 3.68 |
| | Taikokan | 4.56 | 2.23 | 2.28 | 3.02 |
| | Kansaiho | 2.78 | 3.38 | 3.96 | 3.37 |
| | Taikiuyen | 0.25 | 0.24 | 0.44 | 0.31 |
| | Sankakuyu | 0.16 | 2.81 | 4.78 | 2.58 |
| | Yobaireki | 1.04 | 2.20 | 1.75 | 1.66 |
| | Chiureki | 0.73 | 0.92 | 1.66 | 1.10 |
| | Average | 1.65 | 2.77 | 2.32 | 2.25 |
| Giran-cho | Giran | 0.05 | 2.15 | 0.04 | 0.75 |
| | Rato | 0.06 | 0.08 | 0.29 | 0.34 |
| | Heirinbi | 0.15 | 0.43 | 0.86 | 0.48 |
| | Toi | 0.01 | 5.81 | 2.11 | 2.64 |
| | Parisha | 0.65 | 0.38 | 0.30 | 0.44 |
| | Average | 0.18 | 1.77 | 0.74 | 0.84 |
| Taihoku-cho | Taihoku | 2.79 | 4.64 | 3.45 | 3.63 |
| | Shakko | 2.49 | 1.12 | 1.92 | 1.84 |
| | Pankio | 2.75 | 2.87 | 9.56 | 5.06 |
| | Shokiirun | 2.92 | 2.55 | 3.62 | 3.03 |
| | Chosokei | 0.76 | 0.64 | 0.06 | 0.49 |
| | Kimpori | 1.52 | 0.95 | 2.82 | 1.80 |
| | Shinko | 1.77 | 3.35 | 2.10 | 2.41 |
| | Shirin | 6.23 | 5.63 | 4.79 | 5.55 |
| | Shinsho | 0.24 | 14.60 | 52.05 | 22.30 |
| | Tamsui | 1.28 | 2.69 | 1.06 | 1.68 |



| | | | | | |
|---|---|---|---|---|---|
| | Kiirun | 0.01 | 0.59 | 1.38 | 0.66 |
| | Zaicho | 0.0 | 0.01 | 0.07 | 0.05 |
| | Suihenkiaku | 1.3 | 2.44 | 1.64 | 1.80 |
| | Sinten | 1..2 | 0.64 | 0.74 | 0.83 |
| | Average | 1.81 | 3.05 | 6.09 | 3.65 |
| Karenko-cho | Karenko | .... | 2.03 | 0.91 | 1.47 |
| | Bokusekikaku | .... | 1.08 | 1.17 | 1.13 |
| | Average | .... | 1.55 | 1.04 | 1.30 |
| Daito-cho | Daito | .... | 0.18 | 0.94 | 0.56 |
| | Seikoo | .... | 0.01 | 0.07 | 0.04 |
| | Average | .... | 0.10 | 0.51 | 0.30 |
| AVERAGE | | 2.10 | 1.98 | 3.43 | 2.72 |

The above table shows that in only the three prefectural districts of Taichiu, Hokuto and Shinsho has an average of 10 per cent of "white ears" been produced by "Itten-O-Meiga" during the three years. It also shows that the smallest amount of damage occurred in the district of Seikoo, in which only 0.04% of "white ears" were found.

The average of "white ears" throughout the island for the three years was 2.72%, the greatest amount of damage being done in 1912, when the "white ears" numbered, on an average, 3.43 per cent, while in 1911 the least amount of damage was done, when the average being only 1.98 per cent.

If the only damage done by "Itten-O-Meiga" was that which shown by the "white ears", the annual loss would be from 2 to 3 per cent of the rice crop. The loss occasioned by "Itten-O-Meiga" is estimated at from 2% to 3% from damage done just before shooting period to this should be also added the amount of damage done before and after this period which would take the total injury probably as much again.....see Chapter VIII, II, 2.

It is almost impossible owing to varying conditions to obtain an

exact estimate of the actual damage done to the rice crops, but a basis for calculation is afforded by a comparison of the yield from healthy stools with stools infested by "Itten-O-Meiga". From table XXIX we learn that;—

(i) If before the young ears begin to form in the rolled-up leaves the percentage of stems injured is 33.5, then the crops (unhulled rice) will be diminished in weight by a percentage of 21.02%.

(ii) If before the shooting period the percentage of the stems injured is 18.7, the yield of the crops will be diminished 18.91%.

(iii) If during the shooting period the percentage of the stems injured is 22.3, the yield of the crops will be diminished 22.01%.

The calculation of the amount of loss is very difficult and it cannot be made exactly, because the damage at the above three periods sometimes appears separately, and sometimes all, or two together, after transplantation until harvest time.

It is also still more difficult to estimate rates of increase, or of decrease of this insect, since in the field we cannot ascertain with accuracy all the data we require, which must be deduced from figures based on reduction by natural enemies (predaceous and parasitic), weather conditions, and varying methods of cultivation. Between the time of the first and second crops the increase is greatly checked by methods of cultivation, such as cutting down the plants, ploughing, harrowing, and irrigating the field, and also by natural enemies, but, on the other hand, it is certainly a fact that it increases after transplantation until the harvest time in each crop. From my observations it would appear that the larvae are at least twice as numerous before the shooting period as they were at the time when the ears began to form, and a little later, at the actual shooting period they are three times as numerous. After careful observation and calculation it has



been found, that if "white ears" occur in the proportion of one per cent in any crop an annual loss of abc 3.8% of the whole annual crop may be assumed. And since dur...g the last three years "white ears" caused by "Itten-O-Meiga" have been found throughout the island in the proportion of nearly 3% it may be estimated thus damage done to the rice plants by the insect has amounted to no less than 10 per cent of the whole crop.

Let us suppose that a larva injures only one stem, there would still be probably an annual loss of at least over 5 per cent on the crops.

## Chapter VII.
## Distribution and Destructiveness in Formosa.

The distribution of insects in the island of Formosa has not yet been recieved the attention it deserves, but for our purposes the island may be divided into five areas, namely, the boreal, trasitional, subtropical tropical, and oceanic, as shown on the map accompanying this report (pl. 1). "Itten-O-Meiga" is known to occur in all these areas with the possible exception of the Boreal.

It occurs throughout the Transitional area, perhaps even within the limits of the Boreal, but if this be the case it cannot have been sufficiently destructive to have attracted attention. In the Transitional area the injury caused to the first crop is very slight, but it is known to be rather severely injurious to the second crop. Rather serious injury is sustained annually in the province of Taihoku-Cho, where several fields we found infested, from 1% to 24% and in some cases nearly to 80 per cent, when from 10 to 15 larvae were present in each stool.# As we approach the Boreal area "Itten-O-Meiga"

# Two or three young shoots are replanted together in the paddy field, and later about 10 to 20 stems grow up from these — this is what is meant by a stool of paddy.

becomes gradually scarcer, its place being taken by two beetles which are very injurious to the rice plant, namely, *Rice Hispa* and *Rice Lema*.

The Subtropical area on the map indicates, approximately, the principal district where rice is cultivated, and throughout this area "Itten-O-Meiga" occurs abundantly, the species being evidently well-established, and appearing in considerable numbers every year. The insect is undoubtedly a pest of prime importance to the rice crop throughout the Subtropical area, Where an loss of about 10 per cent of the yield is occasioned by the species — small fields were often so badly infested that a larva was found in every stem.

By reference to the map (pl. 1) it will be seen tbat the Tropical area covers a large part of Formosa, and it may be well to divide this area into two subdivisions, namely, a North Tropical subarea and a South Tropical subarea. In the present Report it is necessary to consider these subareas separately.

In the North Tropical subarea, the species occurs moderately abundantly every year and its injury is somewhat severe. In the western coast districts of the northern part of this subarea it is somewhat scarce, while in the southern part it occurs more abundantly. In "Kanten-Den" (i.e., fields which can only be irrigated during the raining season), "Itten-O-Meiga" occurs most abundantly, some fields being infested nearly 100 per cent. Although owing to the high temperature in this subarea, the species feeds up very rapidly, it does not appear to be seriously injurious to the crops, probably owing to the very irregular way in which the paddy is cultivated by the farmers, with the result that in certain seasons many of the moths cannot find rice plants on which to lay their eggs.

In the South Tropical subarea, the injury done by this species is about the same as in the Transitional area, and the larvae feed up still more rapidly. The injury, however, is not very great especially in the southern part of this subarea, and the insect is not considered to be a pest of prime importance to the first crop of the rice; the



same two beetles also occur here as in the Transitional area. With the exception of the southern part of this subarea, the slight nature of the injury done depends probably upon the abundance of the irrigation water which almost exterminates of the insect.

In the Oceanic area, the farmers have only recently commenced to cultivate rice, and although "Itten-O-Meiga" already occurs in the area the damage done has been very slight — perhaps owing to the fact that the rice fields are few and far apart.

The number of generations of "Itten-O-Meiga" which are produced each year varies slightly in the different areas — in the Transitional area 4 or 5 generations occur, in the Subtropical area there are generally 5, and in the Tropical 6.

In Japan this species is well known to the farmers, and is a serious pest of the rice plant, but the amount of the injury done has probably not been ascertained with certainty, and it is however announced officially that the annual loss is from 10 to 20 per cent of the whole crop.

Sufficient data are not, at present, available from China and other countries to discuss the extent and character of the injury done by *Schoenobius incertellus* Wlk, but the few received indicate that it is widely distributed and destructive to the rice fields in India and the Philippines, but it is a much less important pest here than in Formosa and Japan

## Chapter VIII.

## Description and Life-history.

### I. Egg. (Pl. II, 1&12; Pl. IV, 1-5)

### A. Description.

#### 1. Egg-cluster.

The egg-clusters are long and elliptical in form. The free surface are slightly convex, covered densely with the anal tufts of the famale

and the arrangement of the eggs cannot be seen. The attached surface are seen to be flat or roof-shaped, covered slightly with some gelatinous matter which is exuded by the female at the time of the deposition of the eggs. This gelatinous matter melts in hot 5% potash-solution. The length and width vary, as shown in the following table: —

**Table III.** Length and width of egg-cluster.

| No. | Length | Width | Number of eggs. | No. | Length | Width | Number of eggs. |
|---|---|---|---|---|---|---|---|
| | mm. | mm. | | | mm. | mm. | |
| 1 | 7.0 | 4.0 | 79 | 2 | 5.5 | 3.0 | 36 |
| 3 | 8.0 | 3.2 | 83 | 4 | 4.8 | 3.7 | 43 |
| 5 | 7.5 | 3.5 | 52 | 6 | 6.8 | 3.5 | 46 |
| 7 | 8.2 | 3.1 | 92 | 8 | 8.2 | 3.1 | 89 |
| 9 | 5.5 | 3.2 | 54 | 10 | 4.7 | 2.5 | 43 |
| 11 | 7.1 | 3.6 | 68 | 12 | 5.0 | 2.3 | 58 |
| 13 | 4.6 | 3.6 | 32 | 14 | 4.5 | 3.0 | 31 |
| 15 | 8.0 | 3.2 | 107 | 16 | 4.4 | 3.5 | 41 |
| 17 | 5.5 | 3.0 | 58 | 18 | 6.0 | 2.8 | 63 |
| 19 | 6.6 | 3.0 | 63 | 20 | 6.2 | 3.5 | 53 |
| 21 | 8.0 | 3.7 | 114 | 22 | 6.8 | 2.8 | 76 |
| 23 | 6.0 | 3.0 | 47 | 24 | 6.0 | 2.5 | 53 |
| 25 | 6.5 | 3.0 | 44 | 26 | 8.0 | 3.0 | 93 |
| 27 | 8.2 | 3.1 | 62 | 28 | 7.5 | 3.5 | 61 |
| 29 | 6.9 | 3.0 | 44 | 30 | 6.5 | 3.0 | 59 |
| 31 | 4.1 | 2.8 | 46 | 32 | 6.0 | 3.0 | 56 |
| 33 | 6.0 | 2.8 | 50 | 34 | 6.5 | 3.2 | 46 |
| 35 | 4.6 | 3.0 | 37 | 36 | 6.5 | 2.8 | 49 |
| 37 | 7.0 | 3.8 | 74 | 38 | 11.0 | 3.7 | 82 |
| 39 | 7.0 | 3.2 | 67 | 40 | 8.0 | 3.5 | 63 |
| 41 | 6.0 | 3.0 | 52 | 42 | 6.0 | 3.0 | 58 |
| 43 | 4.5 | 2.8 | 36 | 44 | 8.0 | 2.8 | 65 |
| 45 | 7.8 | 3.4 | 66 | 46 | 6.0 | 3.0 | 51 |
| 47 | 6.0 | 3.2 | 55 | 48 | 6.5 | 3.2 | 54 |
| 49 | 8.0 | 4.0 | 85 | 50 | 6.0 | 3.0 | 54 |
| 51 | 4.0 | 2.5 | 37 | 52 | 5.0 | 3.0 | 42 |
| 53 | 7.0 | 3.0 | 57 | 54 | 6.0 | 3.5 | 44 |
| 55 | 7.0 | 3.0 | 56 | 56 | 7.0 | 3.6 | 79 |
| 57 | 6.0 | 3.0 | 56 | 58 | 6.0 | 3.5 | 54 |
| 59 | 7.0 | 3.0 | 94 | 60 | 5.0 | 3.0 | 46 |
| 61 | 9.5 | 3.2 | 112 | 62 | 7.5 | 3.0 | 76 |
| 63 | 6.0 | 3.2 | 73 | 64 | 8.0 | 3.8 | 107 |



| | | | | | | |
|---|---|---|---|---|---|---|
| 65 | 7.0 | 3.5 | 107 | 66 | 7.0 | 2.3 | 80 |
| 67 | 7.5 | 3.0 | 80 | 68 | 4.0 | 2.8 | 32 |
| 69 | 7.0 | 3.5 | 63 | 70 | 3.0 | 2.1 | 31 |
| 71 | 6.5 | 3.6 | 59 | 72 | 7.5 | 3.5 | 97 |
| 73 | 6.5 | 3.0 | 73 | 74 | 6.5 | 3.1 | 79 |
| 75 | 5.0 | 2.8 | 42 | 76 | 5.0 | 2.2 | 43 |
| 77 | 6.0 | 2.8 | 52 | 78 | 8.0 | 3.5 | 98 |
| 79 | 6.0 | 2.8 | 55 | 80 | 6.0 | 3.0 | 60 |
| 81 | 5.5 | 2.8 | 44 | 82 | 5.5 | 2.7 | 51 |
| 83 | 5.0 | 2.9 | 43 | 84 | 5.3 | 2.3 | 52 |
| 85 | 4.0 | 3.0 | 42 | 86 | 6.3 | 2.2 | 56 |
| 87 | 8.0 | 3.2 | 98 | 88 | 6.0 | 2.6 | 44 |
| 89 | 5.5 | 2.5 | 62 | 90 | 6.0 | 3.0 | 44 |
| 91 | 5.0 | 2.9 | 45 | 92 | 6.0 | 3.0 | 48 |
| 93 | 5.0 | 3.0 | 57 | 94 | 4.0 | 3.0 | 31 |
| 95 | 6.5 | 3.7 | 82 | 96 | 6.8 | 3.0 | 81 |
| 97 | 5.5 | 2.8 | 53 | 98 | 5.0 | 3.0 | 41 |
| 99 | 7.0 | 3.2 | 63 | 100 | 4.0 | 2.8 | 33 |
| | | | | Average | 6.3 | 3.1 | 60 |

**Table IV.** Length and width of egg-cluster (from the Special report of the Agricultural Experiment Station of Yehime-Ken, in Japan, vol. II).

| No. | Length | Width | No. | Length | Width |
|---|---|---|---|---|---|
| | mm. | mm. | | mm. | mm. |
| 1 | 8.3 | 4.0 | 2 | 5.9 | 3.6 |
| 3 | 4.0 | 3.0 | 4 | 3.6 | 2.6 |
| 5 | 3.6 | 2.0 | 6 | 1.0 | 0.7 |
| 7 | 6.6 | 2.6 | 8 | 3.0 | 2.6 |
| 9 | 2.0 | 2.0 | 10 | 2.6 | 2.0 |
| 11 | 2.0 | 1.7 | 12 | 2.3 | 2.0 |
| 13 | 2.0 | 1.3 | 14 | 8.3 | 2.6 |
| 15 | 6.0 | 2.3 | 16 | 2.6 | 2.0 |
| 17 | 1.3 | 1.0 | 18 | 1.0 | 0.7 |
| 19 | 3.3 | 2.6 | 20 | 2.0 | 2.6 |
| 21 | 2.3 | 1.3 | 22 | 11.9 | 4.0 |
| 23 | 4.0 | 2.6 | 24 | 4.0 | 2.3 |
| | | | Average | 4.0 | 2.3 |
| | | | Number of eggs on an average....33 | | |

The length of the egg-cluster is 1 to 11.9 mm. and it is on an average 5.2 mm. The width is 1 to 4 mm. and on an average 2.7 mm. The egg-clusters show great variation in length, but little difference in width. The variation depends on the process of oviposition. The number of eggs in a cluster is from 31 to 114 but usually from 50 to 60 This variation is usually proportionate to the size of the egg-cluster; however, this is not always so. The hair-mass on the free surface is 0.2 mm. in depth; its lower layer consists of very short hairs, which are irregularly placed, that is, transversely obliquely, or longitudinally in rows, from below upwards, of course, they are sometimes placed in the opposite direction. This happens when the female rests head foremost on the leaf of the rice plant in oviposition.

The arrangement of the eggs in a cluster is almost regular on the free surface and in the middle of the attached surface. The surfaces have usually three or four rows, but may vary from two to eight. The attached surface, which adheres to the leaf of the rice plant, has one straight row in the middle, if there are an odd number of rows on free surface; and if the rows are an even number, there are usually two straight rows. The eggs are arranged in the cluster on three or four files in the middle part, and on the margins only one or two. They are placed like fish scales on the free surface, and nearly perpendicularly and irregularly in the other portion.

**2. Egg.**

The eggs are flattened and nearly elliptical, but they become irregularly pentagonal or tetragonal, as they are pressed upon each other in the cluster. The variation of their form bepends on their position in the cluster. The eggs situated on the margins of the cluster are nearly round and bigger than the others, which are slightly angular. The surface of the eggshell is smooth, with the micropyle near the large end(sometimes near the small end); around the micropyle it has radiated creases. It is at first nearly colourless, but becomes gradually darker, and five days after being deposited it is



usually blackish. Although the eggs are quite delicate, they are not very easily crushed. Width, 0.11-0.1 mm.; length, 0.13-0.14 mm.; depth, 0.0043-0.005 mm..

## B. Oviposition.

The process of oviposition is not continuous, but is varied by alternate periods of feeding and resting. It is, of course, almost continuous while the female is depositing one egg-cluster. Sometimes she takes a resting time during the oviposition of one cluster; in this case the cluster cannot be formed normally, and it has a narrow portion along the whole length.

Egg laying begins some one or two days after emergence from the stem of the rice plant if the female has been fertilized by the male; otherwise it may be delayed some days longer. Quite often solitary females kept in confinement in the laboratory deposited large numbers of infertile eggs, in this case the egg-cluster is not covered completly with hairs and it is not formed normally, but this probably quite rarely happens in nature.

The fertile female takes up a position for oviposition near the tip of the leaf of the rice plant, keeping her head upwards, and at first she exudes a very pale reddish brown liquid, then deposits the eggs with a colourless viscous liquid, bending the abdomen from side to side. She affixes her anal-tufts on the eggs of for about one or two tranverse rows of eggs, and deposits the eggs of the other row, going upwards gradually.

**1. Time of oviposition.**……The eggs are laid usually in the early part of the evening, between sundown and dark. During the Summer months the female deposits the eggs principally between 7 and 10 p. m., and in the Spring and Autumn months between 6 and 8 p.m.. The moths are not infrequently seen flying and ovipositing on cloudy or dark days, or very rarely even on bright ones, but this is exceptional. The time spent is usually 20-35 minutes; sometimes about one hour is required, but this is quite exceptional.

The appended table gives the percentage of females depositing eggs at the various times, in the laboratory.

**Table V.** Percentage of females depositing eggs, at various times in a day.

| Between sundown and 8 p.m. | Between 8 and 9 p.m. | Between 9 and 10 p.m. | Between 10 and 11 p.m. | Between 11 and 12 p.m. | Between midnight and next morning. |
|---|---|---|---|---|---|
| % | % | % | % | % | % |
| 57 | 11 | 13 | 2 | 1 | 16 |
| 33 | 17 | 17 | 5 | 7 | 21 |

Note. The dotted line shows the observation at the Agricultural Experiment Station of the Prefecture of Yehime in Japan(see the Special Repport, vol.11); the other one shows that made at the Agricultruatl Experiment Station of Formosa (100 ♀).

**2. Position of oviposition.** ··· The female deposits her eggs usually on the under surface of the leaf of the rice plant, about three inches below the tip, touching the midrib. There is no instance in which it is deposited upon the midrib. Quite rarely the clusters are found on the upper surface of the leaf, but this is probably exceptional. The distance of the egg-cluters from the tip of the leaf differs, as the following table shows:—

**Table VI.** Distance of egg-cluster from the tip of leaf. (1000 egg-clusters observed, at various times during the Summer and Spring).

| Distance from the tip of leaf. | Percentage of egg-clusters laid at different positions. |
|---|---|
| 0.6 inch. | 0 |
| 1.2 " | 1 per cent. |
| 1.8 " | 2 " |
| 2.4 " | 13 " |
| 3.0 " | 30 " |
| 3.6 " | 37 " |
| 4.2 " | 8 " |
| 4.8 " | 5 " |
| 5.4 " | 1 " |
| 6.0 " | 3 " |



In the prefecture of Yehime, Japan, egg-cluster were found deposited at 7.5 inches below the leaf tip, and on the sheath also, but this is probably exceptional.

**3. Number of egg-clusters laid by a single female.** .....

Numerous fertile moths were k t under observation at various times during the season to ascertain the number of egg-clusters which would be deposited under different conditions.

Observations on later Spring-moths in the prefecture of Ako, Formosa, seem to indicate that the number of egg-clusters laid by the# is rather small, averaging about two for each moth of a series of 100 which were kept in the laboratory. In Yehime, Japan, however, moths developing from pupae of the second generation averaged about four each for a series of 20 moths.

**Table VII.** Percentage of moths showing number egg-clusters deposited.

| Number of egg-clusters laid by a single moth. | Percentage of moths. | |
|---|---|---|
| | Observation at Ako in Formosa, 1913, from a series of 100 females. | Observation at Yehime in Japan, from a series of 20 females. |
| | % | % |
| 1 | 15 | 0 |
| 2 | 25 | 5 |
| 3 | 41 | 10 |
| 4 | 8 | 25 |
| 5 | 5 | 30 |
| 6 | 1 | 15 |
| 7 | 0 | 15 |

# see the Special Report of the Agricultural Experiment Station, Yehime, Japan, vol. II.

In short, a single female may deposit egg-clusters varying in number from one to seven.

It will be found that a female flies away while engaged in oviposition, whenever it is surprised in any manner. Therefore it is very difficult to ascertain the number of egg-clusters laid by a single

female. From the ratio between the number of eggs laid by a single female and the number of egg-clusters, it is probably not usually over two or three clusters.

### C. Duration of Egg Stage.

During the year 1912 a long series of observations was made in the laboratory, to ascertain the length of the egg stage, at different months during the entire season, and at the natural temperature. In all, the developmental period for 380 egg-clusters (over 13000 eggs) was recorded.

A series of observations was made in the laboratory by Mr. Yano to ascertain this during the Summer of 1906. The results of these observations may be tabulated as follows :—

**Table VIII.** Length of egg stage at each month throughout the season.

| Month of observation | Number of egg-clusters observed. | Number of egg-clusters classified to different durations of egg stage. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 ds. | 5 ds. | 6 ds. | 7 ds. | 8 ds. | 9 ds. | 10 ds. | 11 ds. | 12 ds. | 14 ds. | 15 ds. |
| March | 10 | .... | .... | .... | .... | 1 | 6 | 2 | 1 | .... | .... | .... |
| April | 20 | .... | .... | .... | 1 | 3 | 15 | 1 | .... | .... | .... | .... |
| May | 160 | .... | 2 | 31 | 43 | 45 | 38 | 1 | .... | .... | .... | .... |
| June | 50 | .... | 2 | 7 | 39 | 1 | 1 | .... | .... | .... | .... | .... |
| June x | 7 | .... | .... | .... | .... | .... | 1 | 1 | 2 | 1 | 1 | 1 |
| July | 50 | .... | 5 | 10 | 33 | 2 | .... | .... | .... | .... | .... | .... |
| August | 30 | 1 | 1 | 2 | 26 | .... | .... | .... | .... | .... | .... | .... |
| August x | 15 | .... | .... | .... | .... | 3 | 8 | 3 | 1 | .... | .... | .... |
| September | 50 | .... | .... | 3 | 35 | 11 | 1 | .... | .... | .... | .... | .... |
| October | 10 | .... | .... | ... | 2 | 7 | 1 | .... | .... | .... | .... | .... |

Note. „ x " shows the observation at Yehime, Japan (see The Special Report of the Agricultural Experiment Station of Yehime, Japan, vol. II).

" ds " = days.

In general, it is seen that during the warmer parts of the season the egg stage is much shorter than in the Spring. The shortest egg



stage was only four days in the Summer, and in the Spring and Autumn seven days. The longest one was nine days in the Summer and Autumn, and in the Spring eleven days. It was usually six or seven days ; however, in Japan it is known to be longer than it is in Formosa, varying in extent from eight to fifteen days, but almost always eight to ten days.

### D. Embryonic Development and Hatching. (pl. III).

The egg is fertilized shortly before it is laid, and development begins immediately. The segmentation nucleus is formed within the shell when this is not quite solidified. After about six hours the blastoderm is completely formed and the beginning of the germ band about six hours later causes the appearance of the pale brownish ring when the egg is from eleven to twelve hours old The gastrulation follows immediately on the formation of the germ band. Soon after the segmentation begins, and the formation of the appendages begins when the egg is about two days old About three days after it is laid the body is apparent, indicated by the deeping of the colour, and the true legs and all appendages of the head are formed during the next twenty-four hours. Finally, the deposition of the pigment in the chitinous skin and tubercles causes the blackening of the egg just previous to hatching. The yolk cannot be found around the embryo five or six days after the egg is laid. The head of the fully developed embryo larva is quite plainly to be seen through the egg-shell, as is also more or less of the coiled body. The head is now directly on the inside of the attached surface, which is adherent upon the leaf, and the body of the larva extends backwards with its dorsal surface pressed against the egg-shell. It follows the shell thus down the side, and along each side, until the anal prolegs at the posterior end of the body are just beneath the head. The embryo, in making its escape, bites viciously with its mandibles at the head, tough membranes of the egg, and gradually a spot weakens and the head of the larva suddenly bursts through. It can now easily enlarge the

hole until it is of sufficient size to crawl through. Once this is done the larva must bite through from the back surface of the leaf to which it is adherent. If the egg is laid at the outside of the egg-cluster or in the middle, it is very hard work for it to get free of the cluster. In these cases the larva, at first, makes a hole through its own shell, then it has to make a rather long tunnel through the connections of each shell, and the leaf, and finally it can get free of the cluster. The process, from the first attempt to pierce the egg-membrane until the larva is finally excluded, requires about one or two hours. The hole opened in the shell is of an irregular shape and larger than the head of the larva. This observation was made in May, 1913, at Ako, Formosa.

### E. Infertile Eggs.

Quite rarely, infertile eggs are laid by the females in nature, this, however, happens in rainy or stormy seasons; they are also laid in the laboratory. The changes in external appearance undergone by infertile egg-clusters are sufficiently different from those of normal fertilized ones to merit separate mention. The infertile egg-clusters are not usually covered with hairs completely and are not laid in regular rows, but deposited quite irregularly. One fact is important; from thousands of infertile eggs laid by females in the laboratory not a single one ever hatched or showed the slightest external signs of embryonic development. Almost as soon as they are laid infertile eggs acquire a pale yellowish colour, and within about fourteen hours the whole contents of the shell begin to shrivel up. After twenty-four or thirty-six hours they are always shrunken and acquire a dusky colour. Afterwards they become quite congealed and are very flattened as they contain nothing.

### F. Percentage of Eggs that hatch.

In all lots of eggs laid by fertile females, the percentage that fail to hatch is so small that it was disregarded, except in a few cases where careful counts were made. These shew that of 50 egg-



clusters (371 eggs) two did not develop, giving an average of 0.539 per cent, or about 5 in a thousand. This is doubtless the approximately correct percentage for the hatching of eggs laid out of doors.

The egg-clusters used in this investigation were put, each egg-cluster separately, in a small glass tub and the larvae which hatched were counted. Then the eggs were separated by means of a hot 0.3% solution of potash, and all were counted. The difference between the total number of eggs and the number of larvae hatched out of those egg-clusters, must be the number of eggs which failed to hatch. Of course the percentage of eggs which hatch, in nature, is very small, on account of the natural enemies.

### G. Relation of External Conditions to Eggs,

The external conditions seem to have some effect on the time required for embryonic development. This, however, has probably little relation to the control of "Itten-O-Meiga".

#### 1. Effect of reduced temperatures.

Apart from the numerous records of the length of the egg stage at different seasons, under natural conditions, a few experiments were made to ascertain the effect of much reduced temperature on the development. The first series consisted of sixteen lots which were placed in an ice-box where the temperature varied irregularly between 47° and 58° F. The following table summarizes the results:—

**Table IX.** Effect of low temperatures on embryonic development.

| Number of egg-clusters | Number of eggs | Age of egg. | Time in ice-box. | Remarks. |
|---|---|---|---|---|
| 2 | 81 | Newly laid. | 5 days. | Eggs hatched after 6 days, removed; 39 of them did not hatch. |
| 2 | 107 | do. | 10 " | Eggs hatched after 3 and a half days, removed; 28 of them did not hatch. |
| 2 | 73 | do. | 15 " | Eggs hatched after 2 days, removed; 42 of them did not hatch. |
| 2 | 69 | do. | 20 " | Eggs hatched after 3 days, removed; 58 of them did not hatch. |

It is evident from the figures in the above two tables that eggs which are further developed are less susceptible to the effects of cold, and that the eggs are able to withstand short periods of cold better than longer ones. Some of the larvae hatching from the eggs were kept to see if they had been weakened in any way by the cold, but almost all seemed as healthy as larvae hatched under normal conditions, with the exception of some in the second series.

In nature, the egg-clusters are not exposed to such a low temperature. The effect of high temperatures on embryonic development has not been ascertained, but they may hasten development as compared with normal temperatures.

### 2. Effect of atmospheric conditions.

Moisture and dryness seem to have practically no effect on the embryonic development. A number of eggs submerged for a few days under water, after they were laid, and others placed in a desiccator dried by sulphuric acid, hatched in the same length of time as a check lot under normal conditions. The differences of time required for hatching, are probably due to low temperature. The resistence to atmospheric conditions is no doubt due to the chitinous egg-shell, which prevents the transpiration of water vapour to some extent.

### 3. Effect of storms upon eggs.

A very important factor, however, and one which undoubtedly causes the destruction of immense numbers of egg-clusters, is the mechanical force of the rain during violent storms, which commonly arise in Summer, in Formosa. Although they are rather firmly attached to the leaf, the combined effects of wind and rain washing against the plants removes many egg-clusters. After a tempest, many egg-clusters may be found floating on the surface of irrigation water, during the Summer season in Formosa. Although the eggs in these clusters hatch, the newly hatched larvae cannot find their host plant and must at last die without food. This fact is very often demons-



| | | | | |
|---|---|---|---|---|
| 2 | 123 | 1 day. | 5 " | 121 eggs hatched after 4 days; 2 eggs did not hatch. |
| 2 | 91 | do. | 10 " | 87 eggs hatched after 24 hours; the others did not hatch. |
| 2 | 95 | do. | 15 " | 60 eggs hatched after only 10 hours; 39 eggs did not hatch. |
| 2 | 77 | do. | 20 " | 31 eggs hatched after only 5 hours and 30 minutes; 46 eggs did not hatch. |
| 2 | 82 | 3 days. | 5 " | All the eggs hatched after 36 hours. |
| 2 | 64 | do. | 10 " | 52 eggs hatched as soon as they were removed; 12 eggs did not hatch. |
| 2 | 140 | do. | 15 " | 107 eggs hatched soon after being removed; 23 eggs did not hatch. |
| 2 | 87 | do. | 20 " | 81 eggs hatched soon after being removed; 6 eggs did not hatch. |
| 2 | 99 | 5 days. | 5 " | 97 eggs hatched soon after being removed; the others did not hatch. |
| 2 | 152 | do. | 10 " | 59 eggs hatched soon after being removed; the others did not hatch. |
| 2 | 121 | do. | 15 " | 83 eggs hatched soon after being removed; the others did not hatch. |
| 2 | 122 | do. | 20 " | 21 eggs hatched soon after being removed; the others did not hatch. |

The second series consisted of four lots which were tested in the cold storage of Taihoku Ice Factory Co., where the management very kindly placed at my disposal their vaults for this purpose. The temperature was constantly 32° F. The results were as shown in the appended table :—

**Table X.** Effect of lower temperature on eggs.

| Number of egg-clusters. | Number of eggs. | Age of egg. | Time in cold storage. | Remarks. |
|---|---|---|---|---|
| 2 | 134 | 2 days. | 2 days. | About 90.44 per cent hatched after 5 days, removed. |
| 2 | 142 | do. | 4 " | About 35.21 per cent hatched after 4 days, removed. |
| 2 | 129 | 5 days. | 2 " | Practically all hatched after 2 days, removed. |
| 2 | 138 | do. | 4 " | About 19.56 per cent hatched after one and a half day, removed. |

trated in the rice fields.

**4. Effect of sun on eggs.**

Two experiments were made to ascertain if eggs are destroyed by the direct rays of the sun. In July, 1912, a lot of fifty egg-clusters, newly deposited, were put, with the leaf to which they were attached, on a glass plate, where they were subjected to direct rays of the sun for a week. The eggs were in no way injured, however, and practically all of them hatched normally. Again, a month later, five egg-clusters which were newly laid and the hairs covering the free surface carefully taken off with a forceps were experimented upon in the same manner as in the first experiment. There was no effect on the development, and all hatched after the normal period. The egg-clusters are laid on exposed portions of the rice leaf, in normal conditions, therefore the direct rays of the sun are probably essential to the embryonic development.

## H. Natural Enemies.

Under this head we have to consider a very important factor in the natural control of "Itten-O-Meiga". There are two stages in the life-history of this insect when the destructive work of natural enemies is most effective. These are the imago and the egg. I shall now only discuss the natural enemies of the egg stage. There are rather many species, as described below.

### 1. Parasites.

There are three small species of Hymenopte. which are parasitic on the eggs. Two of them are usually found in Formosa and Japan; the other one is of frequent occurrence in Formosa.

**a. Zuimushi-Aka-Tamagobachi.** (pl. XI, fig 7)

**Trichogramma japonicum** Ashm. (Journ. N. Y. Ent. Soc. xii, p. 165, 1904).

syn. *Neotrichogramma acutiventre*. Girt. (Trans. Am. Ent. Soc. XXXVII, p. 40, pl. 1, figs 11-13).



This minute parastic Hymenopteron belongs to the Family *Trichogrammatidae*, *Chalcidoidea*.

**(1). Description.**

**(a). Imago.**

**Female.** . . . Body yellowish brown to dark brownish, covered sparsely with fine hairs.

*Head.* Normal, somewhat wider than the thorax; transverse, irregularly and slightly strigose; shining, with a few fine hairs. Eyes large, ovate, red, with a very few fine hairs, placed on the front and sides of the head. Ocelli three in number in a broad triangle on the vertex, ruby red; the lateral ones nearly touching the inner margins of the eyes. Antennae 6-jointed, inserted slightly below the middle of the face, where is a triangular elevation on the clypeus; the basal joint small and short, somewhat globular, pale yellowish; scape large, clubbed; pedicel distinctly longer than the first funicular joint, big, brownish yellow; flagellum consisting of one ring joint, two funicle joints and a solid club brownish yellow; pubescence not conspicuous, consisting of soft, short, fine hairs. Face with a broad, longitudinal elevation in the middle; continued to a triangular elevation on the base of the clypeus. Mandibles with five distinct teeth, the three inner ones subequal, longer, the two outer ones about half as long, subequal, all acute, nearly in a straight line.

*Thorax* large, ovate, somewhat shorter than the abdomen, shining, with a few fine hairs; the parapsidal furrows complete, widely separated, straight; pronotum very short, transverse, extending laterally to the radices of the wings; meso-praescutum irregularly strigose but inconspicuous, with two small spines; mesopostscutum and meta-postscutum longitudinally strigose. The former has a pair of spines and is dark coloured.

*Fore wings* large, about two and a quarter times longer than wide, regularly rounded, hyaline, fumated at base as far as the end of

the stigmal vein, the distal margin of the fumated area slightly oblique, involving proximal portions of the discal ciliation; an oblique proximo-caudal curved line of discal cilia running back from the stigmal vein, containing about ten cilia, and slightly caudad to the middle of the wing, joining a nearly similar line running disto-caudad, both forming a bread V-shaped line; discal cilia arranged in from 13 to 20 longitudinal lines, uniform, but not all the lines in regular rows. The marginal vein bears three long, equal setae, and the submarginal vein another of nearly equal length near its distal end; also a smaller one at the base of the stigmal vein and two others, one on the marginal vein near the middle, a long seta, and one on the submarginal vein; a total of seven.

*Hind wings* long and narrow; much shorter than the fore wing; sharply acuminate, acute at the apex; the margins of the blade similar distad to the marginal vein; the cephalic margin acute at the distal end of the marginal vein or at the hooklets; the discal cilia with three principal lines, the two cephalic lines paired and their cilia closer together in the line, near the cephalic margin; the caudal line with the cilia more distant from each other in the line, and that line nearer the caudal margin; marginal cilia normal, those of the caudal margin distinctly longer than the wing is wide.

*Legs* slender, pale yellowish brown to yellowish white; slightly pubescent; coxae largest, shorter than the femora; femora shorter than tibiae; tibiae longer than the tarsi, with a straight spur on the inner side of the end; tarsi three-jointed, all joints of the same length, the claws rather large and two in number, the ventral aspect of tarsi clothed with soft hairs which are moderately long and dense.

*Abdomen* six-segmented, along the middle about equal in length to the head and thorax combined, moderate in length, from dorsal aspect acutely triangular, from the lateral aspect conic ovate, the venter oblique; the first to the fourth segments nearly equal in



length; fifth longest; sixth smallest and nearly pointed. The valves of the ovipositor borne along at least the distal two-thirds of the venter of the abdomen, and not projecting distinctly beyond the tip of the abdomen; usually bent underneath the abdomen, slightly inserted. Cilia of the last pair of spiracles conspicuous, projecting from each side of the tip of the abdomen.

Length, 0.35-0.6mm.

**Male.** — The same, usually smaller and paler than the female. Antennae five-jointed, the two funicle joints but indistinctly indicated, forming together with the club along, spindle-shaped, knotted or nodular club joint, with long soft hairs; composed of basal joint, scape, pedicel, one ring joint and long funicular club. Abdomen slender, acute. Length, 2.31-0.30 mm.

### (b). Pupa.

At first yellow, becoming gradually blackish brown in tint, and one or two days after emergence nearly the same as the imago in colour.

## (ii). Life-history.

Although the number of generations in the year is not yet established, it is quite possibly more than ten. The imagos seem to dislike the dark side of fields, and are almost always found near the tip of the leaf of the rice plant. They are always prowling about their host. As a rule their flying is very poor. They do not usually fly for two or three feet the tip of one leaf to another, but they creep round the surface of the leaf, resting their wings on the back. The females are not active in finding the host. Although the egg-clusters of "Itten-O-Meiga" are quite near to them, they very often cannot find them. Whenever the female finds a newly laid egg-cluster of *Schoenobius incertellus*, she will lay her eggs inside the eggs, her sharp ovipositor being capable of piercing the hard shell of the egg. As a rule two or three females are gathered on an egg-cluster of "Itten-O-Meiga". If too many females meet on an egg-

cluster they all struggle to deposit their eggs. In each egg of "Itten-O-Meiga" is deposited a single egg of the parasite. The number of eggs laid by a single female is 24 to 61, in the laboratory, and it is on an average 43, according to observations made with ten females. These observations were made in ten large glass lamp-chimneys, each chimney was put on a pot which was specially planted with one or two young rice plants. Two or three fertile females of "Itten-O-Meiga" and a couple of the Hymenoptera were put in each of the chimneys. Afterwards the minute Chalcid flies appeared in these chimneys and were counted as mentioned above. The females selected quite newly-deposited eggs, they never laid their eggs in eggs of "Itten-O-Meiga" over two days old, in Formosa. According to investigations made by Mr. K. Nakagawa# it has been proved that in Japan the females deposit their eggs four or five days old eggs of "Itten-O-Meiga".

The young parasitic grubs eat out the contents of the egg. After four to seven days from the time when the eggs were deposited, the grubs pupate in the egg-shell of "Itten-O-Meiga", and after one to three days the Chalcid flies come out, during May and August. In Spring and Autumn, however, a generation required from one to two weeks to be completed.

**(a). Length of the adult stage.**

Observation in nature is very difficult and practically impossible. The observation was made in a large glass tube, $1\frac{1}{2}$ feet in diameter which was put over a pot planted with rice plant; and many quite newly emerged Chalicid flies were put in this glass tube. No special food was provided for the Hymenoptera, and the tube contained no eggs af "Itten-O-Meiga". This was repeated five times during the late Spring of 1913. These observations shewed the length of the

# see the Special Report of the Agricultural Experiment Station, Nishigahara, Tokio, vol. xxxi.



adult stage to be about a week, varying in extent from four to fifteen days. During the Summer a similar observation was again tried three times, but the eggs of "Itten-O-Meiga" were put in the glass tube. During the observations all Trichogramma died in from three to seven days.

It has also been noticed, according to an observation of Mr. K. Nakagawa#, that the Chalcid flies live usually about a week if a 20% solution of honey and moisture be provided for them. In all the above-mentioned observations it was shown that the males usually live longer than the females, and that a single male has a capability of fertilising four females.

In short, the length of the adult stage is probably at least over a week in nature, and the males probably live longer than the females.

**(b). Kinds of host.**

In general it is noticed that the parasitic Hymenopteron has two hosts, viz:— eggs of *Schoenobius incertelius Wlk.* and *Chilo simplex* Wlk. Although I did not find other hosts in Formosa, two other pyralid hosts were found by Mr. K. Nakagawa in Japan(see Spec. Rep. Agr. Exp. Stat. Nishigahara, Japan, vol. xxxi), but this fact is not generally known.

**(iii). Percentage of eggs of "Itten-O-Meiga", parasitised by the Trichogramma.**

The following tables, compiled from a large number of records of my observations, show very graphically the large percentage of eggs of *Schoenobius incertellus* which fail to hatch on account of these parasites.

Note:— A. ..... Zuimushi-Aka-Tamagobachi.
B ..... Zuimushi-Kuro-Tamagobachi
C. ..... Ruriiro-Kobachi.

# see the Special Report of the Agricultural Experiment Station, Nishigahara, Japan, vol. xxxi

**Table XI.** Percentage of eggs of "Itten-O-Meiga", parasitised. (1911).

| Date collecting egg-clusters of "Itten-O-Meiga". | Number of egg-clusters of "Itten-O-Meiga", observed. | Number of larvae of "Itten-O-Meiga", hatched. | Number of Hymenoptera which emerged. | | | Percentage of eggs of "Itten-O-Meiga" which parasitised. | | | Locality |
|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | A | B | C | |
| | | | | | | % | % | % | |
| 4th July | 11 | 253 | 207 | 0 | 0 | 45.00 | 0 | 0 | Taihoku |
| 13th July | 47 | 1011 | 829 | 147 | 0 | 41.71 | 7.38 | 0 | " |
| 16th July | 16 | 293 | 144 | 36 | 0 | 30.44 | 7.61 | 0 | " |
| 2nd July | 15 | 203 | 330 | 90 | 60 | 48.17 | 10.23 | 8.78 | Taichiu |
| 3rd July | 30 | 270 | 620 | 36 | 67 | 62.43 | 3.62 | 6.74 | " |
| 4th July | 25 | 257 | 346 | 130 | 55 | 43.90 | 16.49 | 6.98 | " |
| 5th July | 20 | 597 | 572 | 86 | 0 | 45.57 | 6.45 | 0 | " |
| 6th July | 15 | 416 | 450 | 97 | 42 | 44.77 | 9.65 | 4.18 | " |
| 7th July | 5 | 131 | 97 | 70 | 0 | 32.55 | 23.49 | 0 | " |
| Observed average parasitised during 1911 | | | | | | 45.26 | 8.71 | 2.82 | Formosa |

**Table XII.** Percentage of eggs of "Itten-O-Meiga", parasitised. (1912).

| Date collecting egg-clusters of "Itten-O-Meiga". | Number of egg-clusters of "Itten-O-Meiga" which observed. | Number of larvae of "Itten-O-Meiga" which hatched. | Number of Hymenoptera which emerged. | | | Percentage of eggs of "Itten-O-Meiga" which parasitised. | | | Locality |
|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | A | B | C | |
| | | | | | | % | % | % | |
| 23rd March | 200 | 8592 | 2250 | 232 | 0 | 20.31 | 2.09 | 0 | Taihoku |
| 3rd April | 10 | 373 | 3 | 158 | 0 | 1.66 | 29.25 | 0 | Taichiu |
| 4th April | 19 | 553 | 9 | 294 | 0 | 1.05 | 34.33 | 0 | " |
| 5th April | 26 | 888 | 6 | 237 | 0 | 0.53 | 20.95 | 0 | " |
| 6th April | 24 | 933 | 42 | 355 | 0 | 3.15 | 26.69 | 0 | " |
| 7th April | 21 | 693 | 20 | 317 | 33 | 1.87 | 29.81 | 3.10 | " |
| 14th Feb. | 10 | 373 | 19 | 18 | 36 | 4.93 | 4.70 | 8.07 | Hozan |
| 16th Feb. | 4 | 137 | 24 | 0 | 3 | 14.63 | 0 | 1.82 | " |
| 17th Feb. | 4 | 165 | 4 | 0 | 23 | 2.08 | 0 | 11.97 | " |
| 18th Feb. | 17 | 568 | 37 | 0 | 60 | 5.55 | 0 | 9.00 | " |
| 27th June. | 100 | 4997 | 1311 | 1822 | 0 | 16.13 | 22.41 | 0 | Taihoku |
| Observed average parasitised during 1912 | | | | | | 14.17 | 13.06 | 0.58 | Formosa |



**Table XIII.** Percentage of eggs of "Itten-O-Meiga", parasitised. (1913).

| Date collecting egg-clusters of "Itten-O-Meiga". | Number of egg-clusters of "Itten-O-Meiga" which observed. | Number of larvae of "Itten-O-Meiga" which hatched. | Number of Hymenoptera which emerged. | | | Percentage of eggs of "Itten-O-Meiga" which parasitised. | | | Locality |
|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | A | B | C | |
| | | | | | | % | % | % | |
| 16th March | 25 | 636 | 356 | 39 | 0 | 34.52 | 3.78 | 0 | Taichiu |
| 17th March | 25 | 897 | 255 | 16 | 4 | 21.75 | 1.36 | 0.34 | " |
| 18th March | 25 | 731 | 383 | 24 | 0 | 33.65 | 2.10 | 0 | " |
| 19th March | 25 | 823 | 273 | 0 | 0 | 24.90 | 0 | 0 | " |
| 23rd Jan. | 2 | 107 | 0 | 0 | 32 | 0 | 0 | 23.03 | Hozan |
| 25th Jan. | 28 | 650 | 291 | 42 | 0 | 29.60 | 4.27 | 0 | " |
| 25th Feb. | 8 | 64 | 5 | 0 | 12 | 6.17 | 0 | 14.81 | " |
| July | 19 | 274 | 261 | 0 | 235 | 33.89 | 0 | 30.51 | " |
| Observed average parasitised during 1913 | | | | | | 28.45 | 1.88 | 4.41 | Formosa |

In making these observations each egg-cluster was put in a small glass tube, and the parasitic Hymenoptera which emerged in each glass tube were carefully counted, and the hatched larvae of "Itten-O-Meiga" were also numbered. The sum of the numbers of the Hymenoptera and of the larvae is probably the correct number of the eggs contained in the egg-cluster, because the eggs do not usually fail to hatch, as already stated. The general average of the three tables is compiled as follows:—

**Table XIV.** General average.

| Locality | Crop. | Percentage of eggs of "Itten-O-Meiga" which parasitized by each species. | | |
|---|---|---|---|---|
| | | A | B | C |
| | | % | % | % |
| Taihoku, northern part. | First crop. | 20.31 | 2.09 | 0 |
| | Second crop. | 24.78 | 10.00 | 0 |
| Taichiu, middle part. | First crop. | 14.40 | 15.39 | 0.39 |
| | Second crop. | 48.43 | 9.48 | 4.53 |
| Hozan, southern part. | First crop. | 23.00 | 3.69 | 10.05 |
| | Second crop. | 33.89 | 0 | 30.51 |

According an observation made by Mr. K. Nakagawa, Kumamoto (Japan), it is known that the percentage of egg-clusters parasitised by Zuimushi-Aka-Tamagobachi, in Japan, is forty to seventy-two. The percentage of eggs of "Itten-O-Meiga", which parasitised by the Trichogramma, in Japan, has not been noticed by any student.

In short, of the three egg-parasites of "Itten-O-Meiga" this minute Chalcid fly has the greatest destroying capabilities, in the whole islands and in Japan, and the percentage of eggs parasitised is on an average about 23. In Formosa it appears that the attacks on the eggs are more severe during the second crop season than at the time of the first crop.

**(iv). Breeding in the laboratory.**

Concerning the control of "Itten-O-Meiga", it would be a most important matter if the breeding of this parasite could be completely done in the laboratory. If the eggs of "Itten O-Meiga" or *Chilo simplex* Butl, could be kept ready continuously, breeding in the laboratory would not be very difficult. Although the eggs of *Schoenobius incertellus* are supplied they must be newly laid ones or at least less than two or three days old. As to foods, bananas are probably better than anything else, but a 5% to 11% solution of ordinary honey could be used. Of course moisture is a very important thing. In Japan, it has been noticed, by Mr. K. Nakagawa, that this *Trichogramma* deposits her eggs in the eggs of "Itten-O-Meiga" which are about four days old; but according to an observation of Mr. Yano#, at Yehime, it has been specially noticed that the females be not oviposit in eggs over two days old as is the case in Formosa.

In conclusion, the hosts must probably be less than two days old. The food and egg-clusters must kept in the upper portion of the breeding cage which is made glass, and must be of as great

# See the Special Report of the Agricultural Experiment Station of Yehime-Ken, Japan, vol. I.



a capacity as possible.

**(v). Could the capability of attack on the eggs of "Itten-O-Meiga" be increased?**

This subject is especially important for the ntrol of "Itten-O-Meiga". In Formosa, several experiments were made to ascertain if the capability could be increased. These were as follows:—

a. ..... On a rice field "Itten-O-Meiga" were gathered plentifully by means of lighting (on one night only) many large ordinary oil lamps and placing them in a circular area, 1200 feet in diameter, and allowing the insects to oviposit in the circle. This circular area was divided into one central circular area, and five ring areas which were each 60 feet in width. Over 5000 egg-clusters (Itten-O-Meiga) kept in a large protection-cage* were put in the centre of this circle. These egg-clusters, of course, were newly collected in the field. In each of the areas the whole of the egg-clusters were collected separately during the third and fourth days from the day of lighting, and they were examined very carefully to see how many were parasitised by this Trichogramma.

b. ..... On a rice field in which were deposited numerous eggs, an area six feet square was enclosed and covered with a breeding-cage, made with wire netting with minute meshes. In this cage a number of the Trichogramma were introduced freely. During the third, fourth, and fifth days the whole of the egg-clusters of "Itten-O-Meiga" which were laid in the cage were collected and examined carefully.

c. ..... At the same time 100 egg-clusters of "Itten-O-Meiga" collected on an open rice field were examined. This field

* Protection-cage was made as Plate XIX, fig. IV, for destributing paratitic Hymenoptera, which emerged from the eggs of "Itten-O-Meiga".

was very near to (about 1000 feet distant from) the outer area.

These observations are summarised in the following tables :—

**Table XV.** Percentage of eggs of "Itten-O-Meiga" which were parasitised by each Hymenopteron in each experiment area, 1911.

| Locality | Area | Percentage of eggs of "Itten-O-Meiga" parasitised. | | | Number of egg-clusters, examined. |
|---|---|---|---|---|---|
| | | A | B | C | |
| | | % | % | % | |
| Taihoku | Central area. | 18.1 | 0 | 0 | 4 |
| " | Second area. | 46.2 | 0 | 0 | 3 |
| " | Third area. | 76.8 | 0 | 0 | 6 |
| " | Fourth area. | 30.9 | 13.5 | 0 | 4 |
| " | Fifth area. | 32.9 | 0 | 0 | 9 |
| " | Outer area. | 34.7 | 0 | 0 | 5 |
| " | In the cage. | .... | .... | .... | .... |
| " | Open field. | 32.8 | 0 | 0 | 5 |
| Taichiu | Central area. | 28.6 | 9 3 | 1.9 | 38 |
| " | Second area. | 30 7 | 8.6 | 0.5 | 41 |
| " | Third area. | 28.2 | 7.2 | 1.7 | 40 |
| " | Fourth area. | 29 9 | 13.1 | 0.3 | 42 |
| " | Fifth area. | 30.9 | 6.9 | 2.8 | 41 |
| " | Outer area. | 31.2 | 7.3 | 1.1 | 37 |
| " | In the cage. | 34.6 | 28.0 | 1.9 | 46 |
| " | Open field. | 26.3 | 4.1 | 4.9 | 100 |
| Hozan | Central area. | 23.8 | 2.8 | 14.2 | 27 |
| " | Second area. | 17.4 | 0 | 3.4 | 23 |
| " | Third area. | 23.4 | 0.2 | 18.9 | 40 |
| " | Fourth area. | 33.9 | 0 | 0.4 | 14 |
| " | Fifth area. | 22.2 | 6.5 | 12.9 | 15 |
| " | Outer area. | 12.7 | 0 | 30.4 | 22 |
| " | In the cage. | 14.7 | 0 | 25.1 | 5 |
| " | Open field. | 23.7 | 0 | 16 6 | 48 |



**Table XVI.** Percentage of eggs of "Itten-O-Meiga" which were parasitised by differe- Hymenoptera in each experiment area, 1912.

| Locality | Area | Percentage of eggs of "Itten-O-Meiga", parasitised. | | | Number of egg-clusters, examined. |
|---|---|---|---|---|---|
| | | A | B | C | |
| | | % | % | % | |
| Taichiu | Central area. | 27.6 | 9 7 | 0 | 17 |
| " | Second area. | 41.3 | 12 9 | 0 | 13 |
| " | Third area. | 24.6 | 18.1 | 0 | 16 |
| " | Fourth area. | 31.5 | 1.7 | 0 | 18 |
| " | Fifth area. | 29.8 | 22.3 | 0.1 | 19 |
| " | Outer area. | 23.7 | 10.9 | 0 | 16 |
| " | In the cage. | 36.1 | 14.7 | 0.3 | 42 |
| " | Open field. | 25.05 | 17.1 | 0 | 100 |
| Hozan | Central area. | 0 | 0 | 45.9 | 18 |
| " | Second area. | 0 | 0 | 41.6 | 8 |
| " | Third area. | 0 | 0 | 23.6 | 17 |
| " | Fourth area. | 0 | 0 | 29.6 | 6 |
| " | Fifth area. | 0 | 0 | 51.0 | 6 |
| " | Outer area. | 0 | 0 | 64.3 | 27 |
| " | In the cage. | 0 | 0 | 61.3 | 6 |
| " | Open field. | 0 | 0 | 22.5 | 42 |
| Hozan | Central area. | 0 | 0 | 100.0 | 3 |
| " | Second area. | 0 | 0 | 100.0 | 3 |
| " | Third area. | 16.7 | 0 | 76·7 | 6 |
| " | Fourth area. | 0 | 0 | 100.0 | 2 |
| " | Fifth area. | 0 | 0 | 46.5 | 7 |
| " | Outer area. | 27.4 | 0 | 31.0 | 21 |
| " | In the cage. | 0 | 0 | 91.6 | 4 |
| " | Open field. | 16.7 | 0 | 59.1 | 14 |

**Table XVII.** Percentage of eggs of "Itten-O-Meiga" which were parasitised by *Trichogramma japonicum* at Kumamoto (Japan).

| Series of the experiment. | Number of egg-clusters used in the experiment. | Number of *T. japonicum* used in the experiment. | Percentage parasitised. |
|---|---|---|---|
| I | 1 | 2 | 60 |
| II | 1 | 2 | 40 |
| III | 1 | 2 | 70 |
| IV | 2 | 7 | 80 |
| V | 1 | About 10 | 90 |

This experiment was made by Mr. K. Nakagawa. The egg-clusters laid upon the leaves of the rice plant were put in the glass chimney of an ordinary Japanese lamp, in which many Trichogramma were being kept. Afterwards the egg-clusters being attacked by the Chalcid flies were carefully removed from the chimney, and each cluster was kept in a glass tube and was observed.

In general, the above three tables show that, with a few exception, the capability of the attack of *Trichogramma japonicum* could be increased by means of special protection, especially as will be seen in Table XVII. However, it is doubtful if it could be increased very much. All the above percentage of parasitism are commonly noticed in nature. I cannot believe that in the open field, the capability of attack could be increased very much by means of protections, as is frequently advocated by some people, and according to Mr. K. Nakagawa's declaration. I am inclined to believe that the Chalcid fly has a fixed capability, recognised at the present time, and that it cannot be increased much by means of any protection. Some protection, of course, must be better than none, but it is very doubtful if a proportionate reward could be given for the labour entailed.

**(vi). Natural enemies.**

The Chalcid flies are attacked by numerous enemies, although



how much they are obstructed by the enemies has not been exactly observed. It has been noticed by several entomologists that many species of predaceous insects and spiders prevent the oviposition of the Trichogramma. The chief of these are dragon-flies, especially Agrions. The adults of a few Agrions have been repeatedly observed feeding on the Trichogramma resting on the egg-clusters of "Itten-O-Meiga". These little Agrions are especially abundant in the irrigation ditches of the rice field, and are often seen frequenting sugar cane fields also. Although in a number of instances noticed in the rice field they seem loth to attack other insects; they are sometimes to be seen in the laboratory feeding on the adults of any minute insects. Their principal injuriousness lies, however, in the large number of the Chalcid flies destroyed by them in the rice fields. A special count was made at Ako, Formosa, in May 1913, to determine the probable proportion of adults destroyed by this agency. When about a hundred Trichogramma kept in a glass tube, were set free on a rice field, it was observed that almost all the Chalcid flies were captured by three Agrions. Adults of a few Libellulids were observed on several occasions feeding upon the Chalcid flies, and they probably do so very generally. They must, certainly, be great gluttons; they probably take the second position as destroyers of the Trichogramma, as they are usually less abundant than the Agrions on the rice fields in Formosa. At Yehime, Japan, it is noted by Mr. S. Yano, that Libellulid adults ate up almost all Trichogramma which were set free from a breeding cage.

In the rice fields a kind of spider is very often found which deposits its eggs in the nest made in a leaf tip bent downwards. These spiders feed on Chalcid flies and other minute insects living on the rice leaf. Whenever the Chalcid flies which are emerging from an egg-cluster of "Itten-O-Meiga", are found by the spiders, these capture almost all. Two other species spiders are sometimes noticed by us, feeding on Trichogramma, but not abundantly. In addition,

I must mention that *Paederus idae* which belongs to the Family *Staphylinidae* (Coleoptera), sometimes captures the Chalcid flies, but it does not seem to be a serious enemy.

Although it has been supposed that a disease or a hyperparasite might attack the Trichogramma in nature, these not yet been found by myself or by any student.

It has very often been observed that the Chalcid flies have been unable to oviposit and have died fruitlessly by reason of storms and floods; also that they have been unable in some cases to escape from the fine threads of silk which hang from the mouths of newly hatched larvae of "Itten-O-Meiga".

In short, the increase of the Trichogramma is unfortunately prevented by several natural enemies. The percentage has not yet been ascertained and it may be entirely impossible to estimate it.

## (Vii). Geographical Distribution.

In Japan and Formosa the Trichogramma are widely distributed throughout the plains where the rice plants grow. When I travelled in China, in 1909, I found the Trichogramma attacking the eggs of "Itten-O-Meiga".

The following list will indicate more exactly the localities where the species is known to occur:—

**Japan:-** Fukui; Shiga; Oita; Hiroshima; Nagano; Yamaguchi; Shimane; Yamagata; Aichi; Saga; Kagawa; Nagasaki; Kumamoto; Tochigi; Miyagi; Hiogo; Yamanashi; Nara; Tokushima; Okayama; Tottori; Wakayama; Kagoshima; Osaka; Naha; Tokio.

**Formosa:-** Taihoku; Toyen; Shinchiku; Bioritsu; Tamsui; Kiirun; Taichiu; Nanto; Horisha; Shoka; Kagi; Seira; Taimokko; Yensuiko; Tainan; Takao; Hozan; Ako; Koshun; Giran; etc.

**China:-** Amoi; Suwatow; Canton.

In other countries it is not known to occur.



b. **Zuimushi-Kuro-T magobachi.** (pl. XI, fig. 3).

**Ceraphron beneficiens** Zehnt., Levenswijze in bestrijding der Boorders (Arch. Java-Suikerind, 1896).

Van Deventer, W. ... De dierlijke vijanden van het Suikerriet en hunne patasiten. Tweede diel van het Handbock ten dienste van de Suierrietcultuur en de Rietsuiker-fabricage op Java), Amsterdam, p. 120 pl. 18, fig. 11, 1906.

Krueger, Dr. W. — Das Zuckerrohr und seine Kultur, p. 350, fig. 46.

This minute parasitic Hymenopteron belongs to the family *Proctotrypidae*.

## (i). Description.

### Female.

*Head* shining, black, covered sparsely with fine hairs, nearly as wide as the thorax. Eyes elliptical, bearing a few fine hairs, dark, situated on the sides and rather dorsal. Ocelli round, yellow, three in number, lateral ocelli much nearer to the anterior ocellus than to each other and nearly touching the nearest eye margin. Face a little concave, in the middle a small lozenge-shaped elevation, extending to the clypeus with a narrow and elliptical carina. Clypeus small, with a small triangularly pointed process on the base. Mandibles moderate, yellowish brown, curving outwards and pointed. Antennae black, 12-jointed; the basal joint narrow and slightly curved, almost two-fifths the length of the scape; scape longest, very slightly curved like an S, extending nearly to the anterior ocellus; pedicel very short and as long as the basal joint; flagellum almost club-shaped, the first, second and third joints nearly the same in length and form, globe-shaped, half as long as the pedicel, the fourth joint smaller than the third, the further joints widened gradually towards the end, the eighth and ninth joints widest and of equal length, the terminal joint long and conical, narrower than the joint

below it.

*Thorax* black, nitid, nearly ovate, bearing fine hairs. Pronotum very short and transverse; meso-praescutum rugulose, meso-scutellum and meta-scutellum longitudinally scabriculous.

*Wings* hyaline. Fore wings racket-shaped, large, reaching further than the end of the abdomen; discal cilia pale yellowish, marginal cilia long, absent on the inner margin; marginal vein bears long, almost equal setae; submarginal vein thick, reaching two-thirds along the costal margin; stigmal vein situated between the middle of the costal margin and nearly in the middle of the wing. Hind wings nearly half as long as the fore wings; the costal margin slightly curved inwards, the inner margin very slightly curved like an S, the outer margin round; the discal cilia pale yellowish, the marginal cilia long, especially on the inner margin; the marginal vein with long setae, cilia absent.

*Legs* moderate, pale yellowish brown. Anterior legs:- femora largest, bearing a large spine on the outer margin at the end; tibia shorter than the femur, clavate, bearing a large spine on the inner margin at the end; tarsi slender, 5-jointed, black with two claws, the first joint nearly equal in length to the following four joints together, the terminal joint larger than the second, third and fourth joints. Middle legs:- nearly the same as the anterior legs; femora nearly as long as the tibiae; tarsi nearly as long as the tibiae, the first joint $\frac{1}{2}$ as long as the following four joints together. Posterior legs larger than the two anterior legs; tibiae a little longer than the femora; tarsi longer than the tibiae, the first joint nearly as long as the second, third and fourth joints together, the second, third, fourth and terminal joints nearly the same in length, the latter a little bigger than the others.

*Abdomen* ovate and pointed, without pedicel, nearly as long as the thorax, nitid, black, covered sparsely with fine hairs; the first segment small, the posterior margin strongly curved forwards; second segment



largest, nearly two-thirds of the whole of the abdomen in length, its anterior margin and the posterior margin of the first segment with a transverse comb-like arrangement of sulci; the following segments of nearly equal length; the last dorsal segment small and nearly conical; ovipositor rather large.

Length 1.1 mm.

**Male.**

Compared with the female, the chief differences are as follow:— Antennae 13-jointed; flagellum catogenous and pilose, each joint from the first to the fourth longer than the width, each joint from the fifth to the tenth globular, the terminal joint conical and nearly twice the length of the tenth joint; colour of the body rather paler. Lehgth 1 mm.

**(ii). Life-history.**

The number of generations may be more than eight. The adults seem to like the light sides of the fields, and they are usually found near the top of plants. The Ceraphron is rather active compared with the Trichogramma, but it seems to have great difficulty in finding the host. Although this minute Hymenopteron finds the egg-cluster of "Itten-O-Meiga" it is very often seen that the female cannot oviposit on account of the wind. The manner of oviposition is the same as that of the Trichogramma, but it always seems to require more time. The number of eggs laid by a single female is on an average twenty-two, varying from seventeen to thirty-seven in the laboratory; in fields it may, of course, be more than this. The female lays a single egg inside each egg of "Itten-O-Meiga". After one or two days the parasitic grub hatches and begins to eat the contents of the egg. After two or three days the grub matures, and then pupates in the egg-shell. One generation requires about seven or eight days during Summer and late Spring. During Summer the adults as a rule live over ten days in the laboratory (observed in the same experiments as those of the Trichogramma).

The Ceraphron oviposits on the eggs of "Itten-O-Meiga" or *Chilo simplex* in Japan and Formosa, and it also attacks the eggs of sugar cane Pyralids (*Diatraea striatalis, Suell*, etc.) in Formosa and Java. In Formosa these minute parasitic Hymenoptera chiefly attack the eggs of sugar cane Pyralids, during the Winter.

The capability of attack on the eggs of "Itten-O-Meiga" is less than in the case of the Chalcid flies, and the percentage of eggs of "Itten-O-Meiga" parasitised is on an average 3.55, as already shown on Table XI, XIII; and Table XIV shows that on the first crops fewer of the Ceraphrons (with the exception of those at Taihoku) emerged from the eggs of "Itten-O-Meiga" than on the second crops. In the northern parts of Formosa the minute parasitic Hymenoptera are usually found much more plentifully than in the middle parts, and in the Southern parts they are very rare. According to Mr. K. Nakagawa, the Ceraphron is, as a rule, very rare in Japan. The Ceraphron hase very rarely emerged with the Trichogramma out of the same egg-cluster of "Itten-O-Meiga"; both, of course, cannot attack the same egg. The breeding of this minute Ceraphron in the laboratory, like that of Trichogramma, is not a very difficult matter, and the increase of its capability of attack by means of protections is also nearly the same as that of the Trichogramma. (see Table XIV, XV and XVI)

### (iii). Natural Enemies.

According to the observations made recently the natural enemies of the Ceraphron are exactly the same as those of the Trichogramma, but the percentage attacked seems much more.

### (iv). Geographical Distribution.

The following list indicates the localities where the species is known to occur:—

**Japan:-** Shiga; Ishikawa; Fukui; Hiroshima; Shimane; Yamagata; Nagasaki; Niigata; Osaka; Aichi; Nara; Tokushima; Okayama.



**Formosa:-** Taihoku; Toyen; Taichiu; Shoka; Hozan; Tainan; etc.
**Java:-** West Java.

### c. Ruriiro-Kobachi. (Pl. XI. fig. 2).

### Tetrastichus sp.

This minute parasitic Hymenopteron belongs to the family *Tetrastichidae, Chalcidoidea.*

### (i). Description.

**Female.**

Larger than the two species mentioned above, blackish blue, nitid, more or less blackish brown on the ventral surface.

*Head* very short, transverse, placed perpendicularly, the surface closely punctate, with a few fine hairs. Eyes large, ovate, black. Ocelli three, in a curved line; the anterior ocellus larger than the lateral ones, on the middle of the vertex; the lateral ocelli situated nearly touching the eye margin. Mouth parts more or less produced below, shining purplish brown; clypeus slightly convex, with a longitudinal carina, which is produced to below the anterior ocellus and its sides finely sulcate. Mandibles yellowish, narrow, curving outwards, the ends pointed. Antennae rather thick, geniculate, pale blackish brown, eight-jointed; the basal joint nearly globular, small; scape slender, pale yellow, curved inwards, reaching nearly to the vertex; pedicel sometimes pale yellowish brown, short, and about one third as long as the scape, fig-shaped; flagellum covered with short hairs, cylindrical and of nearly equal length, the terminal joint conical.

*Thorax* gibbose, closely punctate. Pronotum very short, transverse, the lateral ends visible from the dorsal surface only. Mesopraescutum small; meso-scutum largest, tetragonal, the posterior margin shorter than the other margins; scutellum large comparatively, the posterior margin slightly rounded. Metanotum nearly oblique.

*Fore wings* broad, not reaching to the end of the abdomen, hyaline, bearing rather close, discal cilia; marginal cilia rather long especially long on the outer and inner margins; marginal vein bears few setae;

submarginal vein nearly as long as the marginal vein, with a stigmal vein in the middle.

*Hind wings* very narrow, sword-shaped, the costal margin curved obtusely the inner margin slightly curved; the end pointed; the discal cilia rather close, the marginal cilia very long on the inner margin.

*Legs* short, pale yellowish white, end of tarsi brownish, bearing fine hairs; tarsi 4-jointed, each joint of nearly equal length; tibiae with a spine at the end.

*Abdomen* nearly conical, nearly as long as the head and thorax together, without pedicel, 8-segmented; the fourth and fifth segments widest and longest. Ovipositor pale yellowish brown, very short and rather thick.

Length 1.6-1.8 mm.

**Male.**

Nearly the same as the female, but differs chiefly as follows:— Smaller than the female; antennae 9-jointed, nearly catogenous, pale yellowish brown, basal joint very small and globular, scape rather long, pedicel somewhat globular, flagellum covered with hairs ··· the first joint nearly globular, the others nearly elliptical; abdomen much narrower than the thorax, somewhat cylindrical, the base and the apex narrower than the rest. Length 1.4-1.5 mm.

**(ii). Life-history.**

There are probably more than ten generations in a year, and the life-history is nearly the same as in the above two species. The Tetrastichus always requires many more days to complete a generation than the other parasites. Although the female is evidently prompt in finding the eggs of "Itten-O-Meiga" the increase seems to be very poor. The adult lives about two or three days more than the other two parasitic Hymenoptera in the laboratory. This species is found in both fields and forests, though it is not known to attack other kinds of eggs. It is possible that it may attack other eggs



as well as those of "Itten-O-Meiga. Table XI-XIII show that the percentage of eggs of "Itten-O-Meiga" parasitised by this parasite is much less than that of the other two species, but that is a very useful friend to rice cultivation, in the southern parts of Formosa. In the northern parts of the Island it is not known to occur, and it occurs rather rarely in the middle parts. Although its emergence on the first crop is rather small, on the second crop it is about four times greater than on the first, as shown in Table XIV, XV and XVI show that the capability of attack on the eggs of "Itten-O-Meiga", with a few exceptions could be increased much more than the others by affording protection. This species attacks the same egg-clusters as the other parasites, it is rather rare, however, and did not usually emerge from an egg-cluster with the others. Breeding in the laboratory is not very difficult according to several experiments at Ako during 1912, and was found to be much easier than in the case of the others.

Probably the natural enemies of this species are nearly the same as the others, but Tetrastichus has not been observed to be much attacked by enemies.

**(iii). Geographical Distribution.**

In both Japan and the northern part of Formosa it is not known to occur, and it is usually found further south than the middle of the Island. I found when I was examining the egg-clusters sent by Mr. T. B. Fletcher that in the southern part of India the eggs of "Itten-O-Meiga" are parasitised by this minute Hymenopteron to a great degree. It is probably a species which belongs to the Tropics. The following is a list of the localities where it is known to occur up to the present time.

**Formosa:-** Taichu; Shoka; Kagi; Yensuiko; Hozan; Ako.

**India:-** Coimbatore.

## 2. Predaceous Enemies.

Up to the present time the predaceous enemies which have been observed by our entomologists and by other people are unfortunately very few. They are as follows :—

**A. Ako-Himeari.** (Pl. XI, fig. 4).

**Phidole noda.** Smith, Trans. Ent. Lond. 1874, p. 407(4).

This small ant belongs to the subfamily *Myrmicinae, Formicidae.*

**Description.**

Blackish brown, antennae and legs pale, pilosity yellowish, sparse. *Head* a little longer than broad, the face longitudinally striate, the striae running into reticulation on the vertex and posterior lateral lobes ; cheeks straight to above the eyes, than curved inwards, covex; occipital emargination moderately deep and wide ; the posterior lateral lobes rather short, somewhat divergent ; eyes somewhat below the middle line of the head ; mandibles smooth, shining, sparsely punctured, the masticatory margin slightly dentate ; clypeus narrow, anteriorly transverse, convex, with a medial carina and two indistinct longitudinal carinae on the posterior area, defined posteriorly by a strongly posteriorly curved very distinct carina ; antennal carinae long, divergent, the antennal grooves rather shallow, coarsely rugulose within ; antennae short and slender, the scape extending two thirds of the distance between its insertion and the end of the posterior lateral lobes of the head, a little longer than the antennal groove.

*Thorax* very narrow, transversely reticulate and rugulose above ; pronotum with the obtuse lateral angles, promesonotal suture distinct, strongly curved inwards ; mesonotal transverse groove and ridge distinct ; basal portion of metanotum moderate by short, broadening posteriorly and with a somewhat broad shallow longitudinal groove; metanotal spines rather short, erect and acute. Legs long and slender. *Abdomen* shorter than the head and thorax united : the first node of the pedicel transverse above, emarginate and subdentate, without appen-



dix beneath ; second node rounded above, transversely oval, the lateral angles produced and somewhat acute, four times the width of the first node, above having a few transverse striae, the striae not regular ; the remaining segments very broadly oval.

Length about 5 mm.

♀. Dark brown, smooth, polished and shining, very sparsely covered with fine hairs ; antennae and legs pale. *Head* large, slightly flattened, longer than the width, oval, with a distinct posterior margin ; clypeus covex, transverse anteriorly, posterior margin obtusely produced behind, an indistinct furrow between the antennae ; antennal carinae very short ; mandibles long, curved downwards at first and then inwards, the masticatory margin very broad and dentate. Antennae 13-jointed ; basal joint very small, grobular ; scape slender extending only about one-fifth of its length beyond the top of the head ; flagellum clavate at the apical two joints ; pedicel very short somewhat globular.

*Thorax* long, slightly bi-emarginate in profile ; pronotum strongly round ; mesonotum somewhat square, flat above, rugulose ; the basal portion of the metanotum long, closely punctate ; metanotal spines large, oblique, curved inwards at the tip, acute. Legs slender.

*Abdomen* somewhat long ; pedicel slender, the first node small, its upper margin emarginate and subdentate, without appendix beneath ; the second node large, about twice the width of the first node, smooth ; the remaining segments united a little longer than the pedicel, narrower than the head.

Length 2.4-2.8 mm.

This is common ant in the southern parts of Formosa. The ants probably form their nests under the soil surface. On the paddy field they are usually found in the foot-paths between the rice fields or under the weeds which grow near the fields. Whenever the irrigation water dries up in a paddy field they gather on the rice plants and attack the egg-cluster or newly hatched larvae of "Itten-O-

Meiga ". It has sometimes been observed that they gather on the floating matter on the irrigation water ; this is probably because they wish to reach a paddy plant for their food. They always attack the egg-cluster from one side, and as a rule they do not take off the hairs from the egg-cluster. They are fond of the embryo in the egg, and it seems they rather dislike undeveloped egg-contents. They also attack the larvae living in the stem of the paddy plant. In this case they enter the stem by an entrance hole of the larvae of " Itten-O-Meiga ", and they usually carry away the larvae which they kill themselves. If an egg-cluster of *Schoenobius incertellus* is found by them they will eat it up or carry it away within about one hour. Without doubt this species is one of the most powerful friends, in the control of " Itten-O-Meiga ".

### b. Other Enemies.

It has very often been observed by us that *Paederus idae* attacks the egg-cluster of " Itten-O-Meiga ", it is not powerful as the ant, however (see Chapter VIIII, II, H, 3.).

### 3. Disease.

According to investigations made during the last five years, numberless egg-clusters were examined there were no unhatched eggs, with the exception of the eggs parasitised by Hymenoptera. Even if a disease should, by any chance, be found in Formosa, it would probably not be powerful for purposes of control. The above, however, would apply in the case of a disease introduced by some chance.

## II. LARVA. (Pl. II, fig. 2, 2 & 13 ; Pl. VIII ; Pl. IX and Pl. X)

### A. Description.

#### Stage I.

Newly hatched larva rather dark, covered sparsely with fine hairs, the hairs rather long, especially on the head and the last segment ; head dull brown ; face rather yellowish ; the first dorsal segment covered with a brown, shining cervical shield ; the fourth dorsal



segment white on the front two-thirds. Length 1. 2 mm.

*Head* nearly round, length 0.1973-0.2161 mm., width 0.1864-0.2045 mm., rather flat, the posterior margin strongly curved inwards in the middle ; labrum sinuated on the basal margin. Ocellar spots black, placed in a curved line which is 0.027 mm. in length. Antennae pale yellowish, with nearly colourless base, 2-jointed, length 0.05 mm., cylindrical ; the base 1.015 mm. in width ; the end truncate, with two setae ; on the sides it bears two or three fine hairs. Labrum 0.125 mm. wide and 0,06 mm. long, the frontal margin curved inwards in the middle, the lateral margin rounded, pale yellowish brown. Maxillary palpi rather large, length 0.0621 mm., 5-jointed ; the terminal joint cylindrical, length 0.00909 mm., it bears four fine teeth. Mandibles large, nearly rectangular ; the inner margin bears five short teeth ; the first tooth largest, the fifth tooth a little smaller than the others ; length 0.0417 mm., width 0.0454 mm. Maxillae somewhat rounded at the end, 0.01818 mm. wide, and with two rather large setae near the inner margin of the end, and two slightly outwardly curved fine setae, near the outer margin. Labium small, 0.0231 mm. in length with the clypeus, width 0.0227 mm., the outer margin with three fine teeth, and bearing fine hairs. Labial palpi fine, 2-jointed, with a rather long seta, length 0.03127 mm.

*Body* narrower towards the anal end ; the last segment with two longitudinal, small, dark anal shields on the dorsal surface.

*Legs* dark, 0.1227 mm. in length (with the claws); prolegs 0.1818 mm. in length and 0.0227 mm. in width, with nine or ten hooks on the end, arranged in a transverse or elliptical line.

Forty-six hours after being hatched the length is 3 mm., colour yellowish white ; head and cervical shield blackish brown ; the second and third segment somewhat dark, the fourth segment white at two thirds from the front ; width of body nearly twice that of the newly hatched one.

#### Stage II.

The larvae just beginning to feed after ecdysis: *Head* pale reddish yellow; 0.303 mm.– 0.3636 mm. in width, and 0.3333 mm.–0.38215 mm. in length. Mouth parts reddish brown; mandibles brownish; rum and clypeus pale brown; labial mentum blackish brown; labial pi 0.0599 mm. in length. Ocellar spots black or blackish brown; seven in number on each side, placed in an inwardly curved line; two of them obscure, the largest one 0.01818 mm. in diameter. The mid line of the occiput reddish brown. Antennae 2-jointed, pale yellowish; the first joint thick; the second slender, bearing four setae at the end, two of them two or three-jointed, the others non-jointed, the middle of the outer margin of the second antennal joint always bearing a fine hair. Cervical shield pale brownish; the second and third segments yellowish; the fourth to anal segments slightly darkened, on each dorsal segment a few tubercles which are pale and bear a fine hair; two transverse folds near the posterior margin of each segment. Anal shield obscure, dark; three hours after ecdysis it becomes paler and distinct, nearly as in Stage I. Hooks of the prolegs twelve to sixteen in number. Length 3.5-6 mm.

**Stage III.**

*Head* pale dirty yellow, with a narrow blackish brown posterior margin, width 0.353 mm.- 0.4545 mm., length 0.4848 mm.- 0.584 mm. Mouth parts dark brownish, the base yellowish brown. Mandibles blackish brown, 0.1272 mm. in length and 0.1363 mm in width, the end bearing five round teeth. Maxillae slightly flattened, with few teeth at the end; length 0.08181 mm.; width of the end 0.01818 mm. Maxillary palpi 5-jointed, with four fine teeth at the end, one of which is nearly twice as long as the others; the first joint 0.0829 mm. in length, the second joint 0.03 mm., the third joint 0.0363 mm., the fourth 0.0227 mm., the fifth 0.0181 mm. Labrum yellowish brown, the anterior margin curved inwards in the middle, each end of the curved portion bearing a fine hair, near the outer angles of the labrum there is a hair; length 0.06818 mm., width 0.1363 mm. Antennae



2-jointed the first joint 0.0681 mm. in length, the second joint 0.0682 mm. in length; at the base ometimes a joint appears; the end bears four fiine setae, the two mid setae being 2-jointed, the remaining two are short and bear a hair, at the middle of the outer margin a seta. On the dorsal surface of the body there is an obscure white dorsal line, sprinkled with many irregular pale spots, the ventral surface yellowish white at the segments where the prolegs are placed, the others dark. *Legs* pale yellowish white, bearing sparsely some setae, 4-jointed; the fourth joint bears at the end a pale yellowish curved long claw, which is 0.05 mm. in length, sometimes at the middle of the lower margin of the claw there is a very small tubercle, with a large process which is probably the fifth joint of the leg; the second joint longest; the third joint shorter than the second; the first joint thickest, and nearly as long as the third; the fourth joint narrower and shorter than the third, broadend towards the end, nearly truncate. Prolegs yellowish white, with 16-22 black hooks at the end. Anal prolegs with, at the end, 13-18 black hooks which are larger than those of the prolegs.

Length 6 8 mm.

**Stage IV.**

*Head* 0.5727 mm.— 0.7272 mm. in width, 0.666 mm.—0.772 mm. in length. Ocellar portions 0.1393—0.1818 mm. in longitudinal diameter, blackish brown; 5 ocelli placed in the portion, the three mid ocelli touching each other, the others quite separate, the diameter 0.03636 mm. Basal width of labrum 0.2272 mm.; the anterior margin of labrum curved inwards in the middle, on the lateral and outer margins of this curved portion three fine hairs. Labium large, convex, the surface clothed with very fine teeth and with fine hairs, 0.2272 mm. in width; at the middle an appendage which is bigger than the labial palpi and 0.08181 mm. in length, bearing two fine teeth at the end. Mandibles blackish brown, curved outwards, length 0.2272 mm., width 0.9645 mm., on the inner margin five teeth; the first tooth

broad and short, dividing into three teeth at the end ; the second tooth half as wide as the first, long and triangular ; the third longer than the second, with lower margin waved ; the fourth biggest, and longest, with a tooth on the upper margin and with a fine tooth at the base of the lower margin ; the fifth shorter than the fourth. Maxillae 0.06818 mm. in length and 0.05 mm. in width, viewed from the side, the base curved outwards ; the end curved inwards, with two 2-jointed setae, a curved seta and three straight setae. Labial palpi 0.05454 mm. in length, 2-jointed, with a long seta at the end. Maxillary palpi 0.02372 mm. in length, 5-jointed, joints almost the same in length, narrowed towards the end, the terminal end bearing four fine teeth. Body colouration almost the same as that of stage III. Spiracles elliptically convex, in the middle a long curved blackish brown furrow ; the lateral margins of the furrow pale brown ; length 0.1 mm. Hooks of prolegs brown or blackish brown, 21—27. Anal prolegs with 18 to 23 hooks.

### Stage V.

Milky white, *Head* pale yellowish brown, length 0.8252 mm.—1.0606 mm., width 0.7575 mm.—0.94 mm. Antennae yellowish, 2-jointed ; the first joint thick, nearly half as long as the second ; the second joint rounded at the end, with two short tubercles, the upper one of which has a rather thick appendage, a small seta and a long hair at the end, with two setae at the end of this appendage, the outer one of which bears a fine seta at the end ; the lower tubercle of the second antennal joint bearing one seta ; the outer margin of the joint bearing fine setae. Ocellar spots six on each side ; ocelli round, slightly convex, 0.05454 mm. in diameter, placed in a curved line. Mandibles reddish black, reddish yellow at the base, the form nearly the same as in stage IV but all the teeth are shorter ; width 0.25 mm., length 0.249 mm. Labial appendage yellowish, darker at the base, the end obliquely truncate and with two small protuberances ; length 0.08181 mm., width 0.01545 mm. Labial palpi 0.04545 mm.



in length, yellowish, 3-jointed ; the first joint slightly darker than the others, almost globular ; the second joint longest, cylindrical, with a long hair on the upper margin at the end ; the third joint slightly longer than the first, elliptical, with a long hair at the end. Maxillae yellowish, thick, 0.07272 mm. in length and 0.0409 mm. in width ; at the end three rather thick setae which bear a small tubercle, three slender setae and a fine seta. Maxillary palpi yellowish, 5-jointed, the first, second and third joints short and very thick ; the terminal joint 0.02727 mm. in length and 0.013636 mm. in width, the end with a small rounded tubercle in the middle and with four very small pointed protuberances around the mid tubercle. Submentum round and flat, pale yellow, 0.010909 mm. in width. Legs sparsely furnished with hairs, 0.5151 mm. in length ; the claws yellowish red, swollen at the base, length 0.0075 mm Prolegs very short, with 29—32 hooks.

## B. Number of Moults.

The number of moults is almost always four (except for an ecdysis just before pupation) as has already been stated. Out of three hundred larvae reared in the laboratory at Ako, Formosa, in 1913, 64% could not be observed, 31 per cent moulted four times, 1.7 per cent three times, 3.3 per cent five times, and 0.33 per cent six times, except for an ecdysis just before pupation.

With regard to the 1.88 per cent thus varying, the cause of this variation in the number of moults could always be traced to abnormal conditions. Highly nutritious food and excessive moisture in breeding apparently caused less than the normal number of moults. Three out of five larvae reared on glutinous paddy moulted thus. Moults in excess of the normal were caused by hard food.

The following table will indicate the duration of each stage of the larva :—

**Table XVIII.** Duration of each stage of the larva.

| Stage | Duration. | |
|---|---|---|
| | May, at Ako, Formosa. | July, at Fukuoka,# Japao. |
| I. | 3 – 5 days. | 4 days. |
| II. | 3 – 4 days. | 3 days. |
| III. | 4 – 5½ days. | 4 days. |
| IV. | 5 – 7½ days. | 3½ days. |
| V. | 9½–13 days. | 3 days. |

Table XVIII shows that in Formosa the larva remain longest at Stage V, and that Stage II is the shortest. In Fukuoka, Japan, the duration of the larval instars was nearly equal in each stage, and the duration of the larval period was shorter than it is in Formosa. This evidence is, however, very doubtful, as the duration of the larval period is over twenty days in Formosa, and it is commonly known that it is at least twenty-three days in Japan.

The process of moulting is normal. Before ecdysis the larva stops feeding and makes temporarily a very loose cylindrical cocoon in the stalk of the rice plant, where it remains in an extended condition, slightly arched. In this condition it is very helpless; after two or three hours the moulting usually begins. At the time of moulting the body contracts spasmodically, the skin splits longitudinally at the back of the head, and the head is thrust out. After this the body extends gradually and sheds the old skin by a wriggling motion, down the ventral surface. Five minutes to one hour pass before the larva has shed the skin entirely, and after a few minutes to half an hour the larva comes out of the cocoon entirely and begin to food again. During the moulting the larva always keeps the head upwards, and the old skin is left at the lower end of the cocoon. Very rarely a larva moults without making a cocoon, in Formosa.

# see Report of the Agr. Exper. Stat. Fukuoka-Ken, 1892.



## C. Habits.

### i. Habits of Newly Hatched Larvae.

The newly hatched larvae begin to wander about in search of suitable food, here and there, reaping the epidermis of the under surface of the leaf upon which they happen to be, on the way to a young stem, and passing to repeat the process. They are not satisfied to remain on the leaves, and very often arrive at the tender growing point soon after hatching. They do not long, however, and are soon again on the move after a short interval. If they find a young stalk which has not been attacked, they at once crawl into it, making a very small hole, just large enough to enter, and begin feeding inside the stalk. Otherwise they hang down by a fine thread which is sent forth from their mouths, and the thread is blown by the wind until another paddy plant is reached. This method of removing is done by almost all newly hatched larvae, with the exception of those that find a young stalk soon after they are hatched. Although they often fall on the surface of the irrigation water, they always reach a paddy plant by their wriggling motion or by a stream or the wind. The entrance holes to the inside of the stem are usually opened from the inside of the upper end of the sheath.

During the search for a proper living place many of the larvae perish, in fact, the great majority of them to. A number of times during the later Spring from 240 to 300 eggs (five egg-clusters) or newly hatched larvae placed on five paddy plants yielded only 26 to 29 larvae after a few days. Although this is much in excess of the number of eggs usually laid on five plants, it serves to show what an enormous number of the larvae die, in nature.

In the great majority of cases the newly hatched larvae which come out of the egg-cluster, or under surface of the leaf, go immediately in search of proper food, but very often they turn their attention to the under surface of the leaf upon which the egg-cluster is laid. In this case they start to eat the chlorophyll. This may

large and irregular on the inside of the stem, but on the outside it is usually regularly round, and so small that the larvae cannot do more than just pass through it. The formation of the hole is exactly the same at any stage of the larva, viz:— the exit hole on the inside is irregular and larger than on the outside; the entrance hole is usually regular and the same in diameter both inside and outside.

The larvae on leaving the stem crawl up the leaves immediately, and in confusion, repeatedly stretch fine threads between the lateral margins of the living or harf dead leaves, near the tip. By the contraction of these threads the leaves are rolled, and the larvae conceal themselves in the rolled-up leaves. After a few minutes the larvae cut off the rolled-up leaf at one or two inches below the tip, by gnawing; they then cut off the tip of the cylindrical leaf, thus leaving a moderate length which fits their bodies. After this the larvae crawl about on the plants protruding their head and thorax from the temporary case to search for a proper stem which is thicker than the one occupied before. If they succeed in finding such a stem they immediately fix horizontally their temporary case to the stem with the thread which is sent forth from their mouths and begin to bore through the stem wall again. If they cannot find a suitable stem they hang down from the plant upon which they have been crawling about, by means of a thread, and thus reach the surface of the irrigation water, being in the rolled-up leaf. In this way they may drift (being buffetted by ripples or the current) for from a few to twenty-four hours, generally until they reach a rice plant. Upon this they immediately fix their temporary home in the same manner as that stated above. The empty cases usually remain on the stem until they drop off naturally, by reason of rain and wind.

Such temporary cases are sometimes formed on the stem. In this case the larvae first cut off the tip of the stem, living in it, and then they generally cover the mouth of the temporary case with a



last only a few minutes, or again, may continue for nearly an hour. After this is done the larva begins wandering about in its search for food as stated above.

### 2. Habits of Larvae about a Week Old.

Although the larvae usually live singly in each stalk, there are very rarely found as many as fourteen or fifteen larvae in a stalk. This occurs until about a week after they are hatched, but after Stage II many larvae never live together in a stalk. They always live in the first internode#, and go down to the second node#, eating the tissue of the inside, but not in great quantities. They then injure the inner portion of the second node, to a great degree, this causes the "white ears" or "bleached stalks". After this they make a hole through the node and reach the following internode. The hole is not always straight, but is a very irregularly curved one. If the larvae enter a young plant they reach the lower portion of the plant after three to five days. This causes the bleached tips. In this case they leave the plant and remove to another in the same manner as the newly hatched larvae do during their search for proper food (but not means of a thread).

According to observations made by Mr. Yano*, it is known that they have exactly the same habits in Japan, until two weeks after they are hatched; but in Formosa such a habit does not continue so long. This probably depends on the temperature.

### 3. Habits of Larvae over a Week Old.

The larvae, after a week, come out of the stalk, as soon as they reach the root portion, or if they fined that the stem is unsuitable for feeding upon, or that the node is so hard that they cannot bore through it. In these cases they bore at the upper margin of the node, and then they come out of the stem. The hole is always

# The first internode (or node) counted from the tip of the plant.
* see the Report of the Agricultural Experiment Station, Yehime-Ken, Japan.

cocoon is formed just the lowest defensive membrane. The larvae do not actually pupate at the basal end of the stem, except in the case of dry fields. According to many of the observations in Formosa it is known that the number of the defensive membranes varies according to the different depths of the irrigation water, that is to say, it is usually two to three when the irrigation water is plentiful, and it is frequently only one when there is no irrigation water. According to my observations at Ako, 1913, it is known that the larvae usually spend only about twenty minutes in the formation of one defensive membrane, and that they first irregularly stretch a fine thread from one side of the hole to the other, moving the head up and down, and they then spin a membrane moving the head in several directions. Between two and four o'clock in the afternoon these proceedings were observed, but the formation of the membrane has probably no relation to time.

Very rarely the larvae pupate between the sheath and the stem forming the comparatively thick cocoon during the rainy season. During October and September the larvae do not pupate in the intermediate portion of the stem but they certainly pupate at the base, boring usually no emergence hole, and they spread only one defensive membrane. These facts are dependent on the methods of rice cultivation ; that is to say, in Formosa, the paddy plants are reaped at the lower portion of the stem, in October and September, and before this the irrigation water is usually dried up, therefore the emergence hole and many defensive membranes would be rather useless. In some localities where the paddy plants are customarily reaped comparatively high up it is, however, very often observed that the larvae make an emergence hole, and that in some localities where the irrigation water does not dry up on account of the geographical position, two or three defensive membranes are formed.

### D. Effect of External Conditions.

From an early period it has been well known that the time of



very thin membrane which they spin themselves. Again they begin to cut the stem at a moderate length below and always fall on the water surface as soon as stem is cut off. They, however, crawl about from stem to stem, without dropping off, if the plant upon which they are living is young. That is to say, if the plant is young and short the larvae do not cut off the tip of the stem, but they gnaw the side of the stem partly through at the required length until it falls to the water surface ; they at last cut it off completely and crawl obout the plant.

In these cases entrance holes are usually bored below the node. The removing from beginning to end usually takes over two days, varying from one to three. During the removing the larvae become darker in colour ; this is probably dependent on the chemical rays and the variations probably necessary to protect them from external conditions.

### 4. Habits of Nearly Full-fed Larvae.

Although the stem is not suitable for food the nearly full-fed larvae do not actually come out of the stem, but they go to the basal end of the inside of the stem, under the soil surface, having very little nutriment. The larvae having reached the base turn their heads up and begin to spin a membrane about one-fifth to one-fourth of an inch above the place of pupation. After the spinning of this defensive membrane they form the cocoon, in which they always moult and then pupate, keeping the head up. Before doing this they generally make a large, irregular, elliptical hole through the stem wall, about half an inch to an inch above the pupation place. This is the emergence hole, and it is closed by a defensive membrane which thay spin.

During Spring and Summer the larvae make the emergence hole about one or two inches above the water level ; they of course close the hole with a defensive membrane, and again spin one to three defensive membranes below the emergence hole. In this case the

emergence of "Itten-O-Meiga" varies in a great degree in each year or at each season; the causes of this variation are necessarily complicated. Although we cannot prove it definitely the chief causes are probably the external conditions, especially on the larval stage.

### 1. Effect of Atmospheric Temperatures.

In general it is well known that atmospheric temperatures have a great effect upon the development of insects. During September and October the atmospheric temperature has a great effect upon the development of the larvae in Formosa. This season is the harvest time of the second crop of paddy. It is very often noticed that a great number of larvae cannot reach the ordinary position for hibernation, if the atmospheric temperature is lower than it is in an ordinary year; and that there are many larvae which are not able to make preparations for hibernation, though they have been able to reach a suitable position.

The larvae which unavoidably remain in the intermediate portions of the stem are reaped wit' ' · stems by the farmer, and they certainly die on account of the drying of the stems.

The other larvae which reach a place of hibernation are almost always compelled to rest in the larval stage, having a very poor defensive membrane, until the following preparation-time of the field. Although they are able to pupate successfully they cannot emerge before the preparation time. The preparation of the paddy field is made in the following January and February, by ploughing, harrowing, and irrigating. At this time the poor larvae or pupae are buried under the soil or in the water, and they die miserably. In the other months it is not known what is the effect. The atmospheric temperature, however, has probably no effect upon the development; if it has an effect, it appears to be very slight and not sufficient to affect the larvae and pupae.

In Japan, according to Mr. K. Nakagawa, it is known that the



hibernated larvae are very often frozen to death by reason of the extreme cold.

### 2. Effect of High Temperatures.

Two series of experiments were made by Mr. K. Nakagawa#, to ascertain to what degree the larvae are proof against high temperatures. The appended list summarizes the results:—

(i). If the larvae are kept over thirteen hours in a place which is over 41.7° C. all of them will die.

(ii). If the temperature is 42.8° C. all of the larvae will not die within nine hours.

(iii). If it is less than 41.1° C. the larvae scarsely ever die, though they are kept during 23 hours.

It is known that the temperature in nature is often over 42°. C. in places exposed to the direct light of the sun, in Formosa and Japan. This, however, does not continue over two or three hours.

In short, it is to be inferred that the larvae are very rarely killed by such high temperatures in nature.

### 3. Effect of Dryness.

Experiments were made to ascertain if dryness had any effect on the growth. These gave mostly positive results.

A series was made by Mr. K. Nakagawa#, in Japan, and the experiment showed the following results:—

If the larvae are kept in an ordinary desiccator arranged similarly to one having a power of drying 2279.882 cubic milimeters of water within 24 hours, they die within nine days.

Two other series were made in Formosa. "A" result showed that a degree of dryness less than that mentioned above killed all the larvae within seven days. In this experiment a desiccator was

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# see the Report of the Agricultural Experiment Station, Nishigahara, Tokio (Japan), vol. XXXI.

used and sulphuric acid was employed for the drying medium. It was arranged similarly to one in which 2222.3 cubic milimeters of water could be dried within 24 hours, being kept in a small glass measure. In such a desiccator ten larvae, living in the stems of about five inches in length were laid with the stems. After a week all of them were dead.

In the second series ten larvae living in growing stems planted in a small pot were kept in a desiccator prepared as mentioned above, but they were not dead after a week had elapsed. This shows that if the paddy stems are living, the larvae do not actually die.

In short, the larvae living in the living stems will probably not die in nature, though they are subjected to great dryness. In nature, it seems as if the dryness had no effect on the larval growth except in those cases in which paddy plants wither because of great dryness of the atmosphere.

### 4. Effect of both High-Temperature and Dryness.

Experiments were made by Mr. K. Nakagawa# in Japan. The following list summarizes the results :—

(i). The larvae are killed by the combined powers of high temperature and dryness within five days, though the temperature and dryness within five days, though the temperature was only 31° C.

(ii). If the degree of dryness is equal, the hours in which the larvae are killed are inverse proportion to the temperatures; namely, the hours are proportionately shorter as the temperatures are higher.

In short, the combined powers of dryness and heat had a great effect on the growth of larvae.

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In nature, severe dryness is not usually met with. Although it happens, it is hardly ever so continuous as to cause the paddy plants to wither. Practically it is not known that in Formosa or Japan rice plants are withered by the combined powers of dryness and heat, in nature, when irrigation water is not dried up. No doubt, the larvae are not subject to so severe a degree of dryness and heat that they are killed in the paddy stems. We must infer that only the hibernating larvae can possibly be killed by the combined powers of heat and dryness; because at this time there is very often no irrigation water and the rice plants are nearly or entirely withered.

### 5. Effects of Sun.

The newly hatched larvae or the larvae which are in the act of removing from one to another are very often exposed to direct rays of the sun.

Six series of experiments were made to ascertain if the growth of the larvae is checked or destroyed by the direct rays of the sun. In May, 1913, at Ako, the larvae of each stage were kept separately on paddy leaves fixed in six Petley's dishes, six inches in diameter, and these dishes were placed under the direct rays. During the experiments the larvae which came out to the dishes were driven back with a small paint brush. After a time the larvae were removed to the rice stems and were examined to see how they were progressing. The following table summarizes the results :—

**Table XIX.** Effect of the direct rays.

| Number of larvae examined. | Stage of larvae. | Time kept under the direct rays. | Remarks. |
|---|---|---|---|
| 5 | Newly hatched. | 10 minutes. | Developed perfectly. |
| 5 | " | 20 " | Developed perfectly, but one of them required many hours to bore through the inside of the stem. |
| 5 | " | 30 " | Developed perfectly, but all of them required many hours to bore. |
| 5 | " | One hour. | Three of them died after boring through the stems. The others had not bored through the stems. |
| 5 | " | Two " | None of them had bored through the stems. One of them died, boring the stem. |

| | | | |
|---|---|---|---|
| 3 | I Stage | 10 minutes. | Two developed perfectly. The other died after boring through the stem. |
| 3 | " | 20 " | One bored through the stem. Two died before boring. |
| 3 | " | 30 " | All died before boring. |
| 3 | " | One hour. | do. |
| 3 | " | Two " | do. |
| 3 | II Stage | 10 minutes. | Developed perfectly. |
| 3 | " | 20 " | do. |
| 3 | " | 30 " | Developed perfectly; one of them had great difficulty in boring through the stem. |
| 3 | " | One hour. | One developed. Two died before boring through the stems. |
| 3 | " | Two " | All died before boring. |
| 3 | III Stage | 10 minutes. | Developed perfectly. |
| 3 | " | 20 " | do. |
| 3 | " | 30 " | do. |
| 3 | " | One hour. | Two developed perfectly. One died after boring. |
| 3 | " | Two " | All died before boring. |
| 3 | IV Stage | 10 minutes. | Developed perfectly. |
| 3 | " | 20 " | Two developed perfectly. One died after boring. |
| 3 | " | 30 " | All died after boring. |
| 3 | " | One hour. | One died as soon as removed to the stem. Two died after boring. |
| 3 | " | Two " | All died before boring. |
| 5 | V Stage | 10 minutes. | One pupated in the stem. Two pupated before boring. |
| 5 | " | 20 " | Developed perfectly. |
| 5 | " | 30 " | All pupated before boring. |
| 5 | " | One hour. | do. |
| 5 | " | Two " | Two pupated in the stems. One pupated before boring. |

This table shows that the newly hatched and Stage V larvae had strong defensive powers against the direct rays of the hot sun, and that the larvae in stage I (boring through the stem) were very delicate. It seems as if the larvae are not so delicate as Mr. K. Nakagawa's experiment# shows. In his experiment the larvae were

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kept in glass dishes which were not covered with any sheet at the bottom, therefore they were subjected to both the direct rays and the reflected rays, reflected from the bottom. This is probably one of the causes of the rapid weakening of the larvae.

Mr. K. Nakagawa has noted that the newly hatched larvae die within about 16 minutes, and that the larvae are rather fond of green and blue rays, and hate red, yellow, and orange rays.

## 6. Effect of Water.

In general, terrestrial larvae of insects are much affected by water, but they have almost naturally a defensive power against it. The larvae of this insect are also very clever in escaping from the water and in protecting themselves against it. As regards the larvae living in the stem, it does not usually happen that they are attacked by water. In the removing or hatching times the larvae are very often washed down by rain and submerged for considerable periods. To test their ability to withstand such conditions a number were experimented upon in the field. Fifty newly hatched larvae were entangled in a paddy plant and submerged for six hours. All but seven survived the immersion. Larger larvae, removing without temporary houses, could not stand such long periods, but when dropped into the irrigation water made rather active attempts to escape, becoming stupefied after about an hour. The larvae havin temporary houses were submerged for ten hours. Practically all survived and developed perfectly. The larvae living in the stem have means of protection against water, as stated below.

### (i). In the growing stage.

When the rice plants have stems the entrance or exit holes of the larvae are bored between the first and third internodes; if the

stems are not fully grown up, between one and three inches below the growing tip. Such holes are not submerged in the usual volume of the irrigation water. If there are heavy rains or floods these holes are very often submerged and the larvae are compelled to escape from the water. After floods or heavy rains it will be found that the larvae are removing in large numbers with their temporary houses, and that some of them are dead in the stems. Such dead larvae are usually full-fed or half-moulted in each stage. Very rarely it is observed that temporary defensive membranes are constructed in the stems.

According to these facts it must be concluded as follows:— If the water penetrate through the hole the larvae bore through the stem wall and come out. They then form their temporary houses, as already stated, and begin removing. If the penetration happens before and after, or during the moulting, the larva cannot bore through the stem wall and dies in the stem, very rarely it forms a temporary defensive membrane and almost attains maturity.

### (ii) In the maturing stage.

The protective methods of the mature larvae have been already stated. In the laboratory it was repeatedly proved by observation that two or three such defensive membranes could almost entirely prevent the penetration of the water, and that the larvae are probably not submerged for very long on account of the membranes. If the larvae could be easily killed by the irrigation water, it would be a godsend to our farmers. Several experiments were made to ascertain if the water could be applied as a control. The following table summarizes the results:—

**Table XX.** Effect of submergence. (1908 – 1910).



| Locality | Duration of submergence of paddy stubble. | First series | | | | Second series | | | | Third series | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Larvae | | Pupae | | Larvae | | Pupae | | Larvae | | Pupae | |
| | | Number examined. | Percentage dead. | Number examined. | Percentage dead. | Number examined. | Percentage dead. | Number examined. | Percentage dead. | Number examined. | Percentage dead. | Number examined. | Percentage dead. |
| | | | % | | % | | % | | % | | % | | % |
| Taihoku | 5 days | .... | .... | .... | .... | 5 | 20 | .... | .... | 3 | 0 | .... | .... |
| | 10 " | .... | .... | .... | .... | 4 | 23 | .... | .... | 4 | 23 | ... | ... |
| | 15 " | .... | .... | .... | .... | 1 | 0 | .... | .... | 2 | 100 | .... | .... |
| | 20 " | .... | .... | .... | .... | 3 | 67 | .... | .... | 5 | 100 | .... | .... |
| | 25 " | .... | .... | .... | .... | 5 | 60 | .... | .... | 1 | 100 | 1 | 100 |
| | 30 " | .... | .... | .... | .... | 3 | 100 | .... | .... | 3 | 100 | 1 | 0 |
| | 35 " | .... | .... | .... | .... | 2 | 100 | .... | .... | 2 | 100 | .... | .... |
| | 40 " | .... | .... | .... | .... | 3 | 100 | .... | .... | 3 | 100 | .... | .... |
| | 45 " | .... | .... | .... | .... | 3 | 100 | 1 | 100 | 4 | 100 | .... | .... |
| | 50 " | .... | .... | .... | .... | 3 | 100 | 1 | 0 | 1 | 100 | .... | .... |
| | 55 " | .... | .... | .... | .... | 2 | 100 | .... | .... | 2 | 100 | 1 | 0 |
| | 60 " | .... | .... | .... | .... | 2 | 100 | 1 | 100 | 3 | 100 | .... | .... |
| | 65 " | .... | .... | .... | .... | 3 | 100 | .... | .... | 3 | 100 | .... | .... |
| | 70 " | .... | .... | .... | .... | 3 | 100 | .... | .... | .... | .... | .... | .... |
| | 75 " | .... | .... | .... | .... | 2 | 100 | .... | .... | .... | .... | .... | .... |
| | 80 " | .... | .... | .... | .... | 1 | 100 | .... | .... | .... | .... | .... | .... |
| | 85 " | .... | .... | .... | .... | 3 | 100 | 1 | 100 | .... | .... | .... | .... |
| | 90 " | .... | .... | .... | .... | 2 | 100 | .... | .... | .... | .... | .... | .... |
| | 95 " | .... | .... | .... | .... | 16 | 100 | .... | .... | .... | .... | .... | .... |
| | | | % | | % | | | | | | | | |
| Taichu | 5 " | 114 | 16.7 | .... | .... | 73 | 0 | .... | .... | 72 | 26.3 | .... | .... |
| | 10 " | 63 | 23.8 | .... | .... | 53 | 0 | .... | .... | 60 | 23.5 | .... | .... |
| | 15 " | 95 | 62.1 | .... | .... | 48 | 21.0 | .... | .... | 86 | 47.6 | 3 | 0 |
| | 20 " | 91 | 42.9 | .... | .... | 32 | 31.2 | .... | .... | 79 | 64.6 | 2 | 0 |
| | 25 " | 44 | 22.7 | .... | .... | 134 | 11.2 | .... | .... | 74 | 34.9 | .... | .... |
| | 30 " | 80 | 33.8 | .... | .... | 59 | 50.8 | .... | .... | 58 | 44.8 | 3 | 33.3 |
| | 35 " | 49 | 38.8 | .... | .... | 60 | 25.0 | .... | .... | 110 | 52.7 | 12 | 33.3 |
| | 40 " | 49 | 65.4 | .... | .... | 66 | 66.9 | .... | .... | 57 | 73.7 | 7 | 14.3 |
| | 45 " | 50 | 46.0 | .... | .... | 73 | 49.3 | 1 | 0 | 62 | 66.1 | 8 | 2 |
| | 50 " | 45 | 60.0 | .... | .... | 55 | 60.0 | 1 | 0 | 60 | 75.0 | 3 | 77.8 |
| | 55 " | 35 | 60.0 | .... | .... | 71 | 57.7 | 1 | 0 | 43 | 81.4 | 9 | 55.6 |
| | 60 " | 51 | 72.5 | .... | .... | 68 | 55.9 | 1 | 0 | 14 | 64.3 | 4 | 50.0 |
| | 65 " | 40 | 80.0 | 2 | 0 | 56 | 57.2 | 1 | 0 | 18 | 77.8 | 5 | 20.0 |
| | 70 " | 33 | 87.0 | 3 | 33.4 | 52 | 53.8 | 8 | 50.0 | 24 | 95.8 | 3 | 100.0 |
| | 75 " | 37 | 81.8 | 3 | 33.4 | 47 | 72.3 | 4 | 50.0 | ... | .... | .... | ... |
| | 80 " | 33 | 30.0 | 3 | 66.7 | 59 | 71.2 | 9 | 66.7 | .... | .... | .... | ... |
| | 85 " | 36 | 88.9 | 5 | 80.0 | 80 | 85.0 | 16 | 18.8 | ... | .... | .... | .... |
| | 90 " | 38 | 94.7 | 6 | 50.0 | 72 | 90.3 | 21 | 42.8 | ... | .... | .... | .... |
| | 95 " | 11 | 100.0 | 4 | 100.0 | 46 | 95.7 | 7 | 42.9 | .... | .... | .... | .... |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ilozan | 5 | " | 109 | 5.5 | .... | .... | 79 | 40.5 | .... | .... | 92 | 51.1 | .... | .... |
| | 10 | " | 91 | 20.9 | .... | .... | 110 | 46.4 | .... | .... | 95 | 60.0 | .. | .... |
| | 15 | " | 113 | 51.3 | .... | .... | 82 | 60.9 | .... | .... | 74 | 54.0 | .... | .... |
| | 20 | " | 114 | 59.8 | .... | .... | 111 | 68.5 | .... | .. | 88 | 72.7 | .... | .... |
| | 25 | " | 78 | 55.1 | .... | .... | 94 | 55.3 | .... | .... | 65 | 66.2 | .. | .... |
| | 30 | " | 120 | 65.8 | .... | .... | 101 | 62.4 | .... | .... | 64 | 68.8 | 4 | 75.0 |
| | 35 | " | 117 | 78.6 | .... | .... | 97 | 58.8 | .... | .... | 67 | 80.6 | 2 | 100.0 |
| | 40 | " | 120 | 75.0 | .... | .... | 88 | 12.5 | .... | .... | 99 | 87.9 | 1 | 100.0 |
| | 45 | " | 115 | 69.4 | .... | .... | 92 | 63.0 | .... | .... | 77 | 97.3 | 3 | 33.3 |
| | 50 | " | 126 | 74.6 | .... | .... | 81 | 66.7 | .... | .... | 79 | 96.2 | .... | ... |
| | 55 | " | 102 | 75.5 | .... | .... | 120 | 80.0 | 6 | 16.7 | 58 | 95.7 | .... | .... |
| | 60 | " | 136 | 84.6 | .... | .... | 94 | 81.9 | .... | .... | 51 | 94.1 | .... | .... |
| | 65 | " | 69 | 76.8 | 8 | 62.5 | 27 | 22.2 | .... | .... | 14 | 100.0 | .... | .... |
| | 70 | " | 24 | 87.5 | .... | .... | 27 | 22.2 | .... | .... | 21 | 100.0 | 5 | 80.0 |
| | 75 | " | 19 | 100.0 | 16 | 50.0 | 15 | 26.7 | .... | .... | 16 | 100.0 | .... | .... |
| | 80 | " | 17 | 94.1 | .... | .... | 13 | 100.0 | 1 | 0 | 21 | 100.0 | .... | .... |
| | 85 | " | 21 | 100.0 | 4 | 75.0 | 17 | 94.1 | 1 | 100.0 | 88 | 98.8 | .... | ... |
| | 90 | " | 14 | 100.0 | 5 | 100.0 | 17 | 100.0 | .... | .... | 15 | 100.0 | .... | .... |
| | 95 | " | 134 | 98.5 | 1 | 0 | 110 | 97.3 | 18 | 75.0 | 32 | 93.7 | 3 | 100.0 |

These observations were made after the reaping of the second crops between November and the beginning of the following April. Applying water as a control is practically impossible in any other season. A paddy field which was greatly damaged by this insect was divided into three parts, and each field was employed respectively for each series of observations. These fields were not ploughed, and the paddy stubble standing in the field were kept in that condition. In the first series the paddy stubble was submerged in the irrigation water just after the reaping; in the second series three weeks after the reaping; in the third series six weeks after the reaping.

Table XX shows that the hibernated larvae are relatively strong though their houses are submerged, and that the number of the dead larvae is almost proportionate to the duration of the submergence of the stubble. In the observations it is noticed that pupation was very much later than under usual conditions, especially in the first series; that the larvae remained in that condition, although their houses (stubble) were submerged until May; and that the dead



larvae were found in the decayed stubble and scarcely any in the undecayed stubble.

In short, the water had probably no connection with the death of the hibernated larvae in Formosa, unless their houses (paddy stubble) were decayed. Such larvae, however, could not pupate for a long time.

**(iii). In the case of larvae taken out of the stem and submerged.**

Statements have already been made regarding this case. In addition a little more may be said. When the larvae are dropped into the water they immediately come up below the water surface and reach a paddy plant, swimming irregularly along under the water surface by means of their peristaltic movement. During this time, the larvae have an air-layer on the surface of their bodies and do not become wet. If the larvae are full fed they cannot always reach a plant, notwithstanding that they make feeble attempts to escape from the water.

## 7. Methods of Paddy Cultivation in Relation to the Growth of the Insect.

In our country there are eight methods of cultivation, namely: Double-crop Method; Shabaa Method; Mixed Method; Summer Method; Single-first-crop Method; Single-second-crop Method; Open-sowing Method; Aqua-terrestrial Method.

### a. Double-crop Method.

In Formosa the paddy is usually cultivated according to this method. This means that the paddy is cultivated twice in a year, and the kind of paddy entirely differs at each cultivation. At first the paddy seeds are sown in a bed of rice, and the young shoots are kept on the bed for about fifty to sixty days in the northern parts; about sixty days in the middle parts; and about forty days in the southern parts. After this the young shoots are replanted on the paddy fields in March to April; February to April; and January

to February raspectively in the northern, middle and southern parts. These months concur respectively with the first emergence of "Itten-O-Meiga" at each locality. The first-emerged adults usually lay their egg-clusters on the young shoots growing on the fields or bed. The first newly hatched larvae are usually feeding on the paddy which has not yet grown a stem. When full fed they emerge as the second moths, until the middle of May, the end of April, and the middle of April respectively, in the northern, middle and southern parts of Formosa. In these months the paddy grows up and the stems develop. The larvae of the second generation always feed in the stems, and the third emergences occur until July from June, and from May to June respectively, in the northern, middle, and southern parts. In the northern parts the first crops are reaped in July. At this time a number of the larvae (or pupae) are reaped in the stems and die owing to the drying of the paddy, as they live in the intermediate portion of the stem. This is the reason why the third emergences occur in comparatively small numbers in the northern parts. In both the middle and southern parts the moth of the third generation nearly always emerges successfully because the first crops are reaped about one month after the time of emergence.

The second paddy is cultivated after the same method as the first. The young shoots are replanted in the fields in the latter half of July in the northern parts; and at the end of June to the middle of August in the middle and southern parts. These months correspond to the fourth emergence, but in the northern parts to the third, as stated above. At the reaping time the larvae and pupae remaining in the stems are usually killed on account of the drying of the stalks, and those which remain in the stubble are buried under the soil or water when the preparation of the field is carried out. Therefore the fourth emergences (third in the northern parts) are rather few in number compared with the third (second in the northern parts). The successfully emerged moths oviposit on young



shoots although they are not suitable for the houses of the larvae, as there is no large paddy. At this time the newly hatched larvae of the fourth generation (third in the northern parts) feed on the young paddy growing in the fields or bed. Many of them die as they have not sufficient food (see Chapter VIII, II, F.). The few surviving larvae feed on the second crops and one generation (two in the southern parts) is safely repeated before the harvest. In the northern, middle, and southern parts respectively, the fourth, fifth and sixth generations seriously injure the second crops, and they hibernate in the stubble.

In short, this method of paddy cultivation is only unfavorable to the increase of "Itten-O-Meiga" between the first and second crops. During this time the increases are checked to a great degree, but all other period are very favourable to their increase.

**b. Shabaa Method.**

In this method the young shoots of the first crops are cultivated in the fields in the same manner as in the Double-crop Method. When the first paddy grows up to about seven inches, usually about a month after the replantation, the young shoots of Shabaa (which is one kind of second crop) are replanted between the first plants, with a ratio of three or four stools to five of the first stools. Shabaa seeds are also cultivated on a bed at the end of February or the beginning of March. After replantation both these two kinds of paddy plant grow up together in the same field. In June the first crops are reaped when about eight inches high, as Shabaa are about that height. The second crops, namely Shabaa, are reaped usually in November, meanwhile the stubble of the first plants generally stand in that condition; very rarely, they are buried under the soil or water.

At the Prefecture of Rato, Giran-Cho and in some localities of Taihoku-Cho, Toyen-Cho and Shinchiku-Cho, the paddy plants are cultivated after this method. In these localities the white ears are

usually found in great numbers compared with other localities where Shabaa method is not practised. This is probably due entirely to the method of paddy cultivation. In the fields cultivated by Shabaa method the paddy plants are growing up for a whole year and therefore "Itten-O-Meiga" is able to increase without hindrance, having plenty of food and living in security. Of course, the larvae and pupae which were unfortunate enough to be living in the cut-off stem are killed, on account of the drying of the yields.

In short, this method is certainly a most favourable one for the increase of "Itten-O-Meiga".

**c. Mixed Method.**

In this method the mixed seeds of both first and second crop paddy are sown on a bed in early Spring, and the young shoots are replanted in the field. These proceeding are identical with those commonly employed in dealing with first-crop plants. The proportion of the mixing of the seeds varies; however, there are usually more seeds of first-crop plants than of second-crop plant, the proportion at Giran, for example, being 1 to 10. During June and July the first-crop paddy reaches maturity in the field, and it is reaped about seven or eight inches high. At this time the second-crop paddy is growing slowly, and is about seven inches in height. After this the second-crop paddy grows up and reaches maturity, the harvest time being in November, while the stubble of the first crop, without exception, stands in a living condition. In several localities of Giran-Cho and the Prefecture of Tamsui, Taihoku-Cho, this method is practised in a small area.

Under such conditions, it is also evident that Mixed Method is favourable to the increase of "Itten-O-Meig", and is indeed rather better for them than the Shabaa Method.

**d. Summer Method.**

The method of rice cultivation followed in Japan belongs to the summer Method, and in Formosa is very rarely employed, but



sometimes observed in mountainous fields in the Prefecture of Kiirun. In this method the paddy seeds are sowed on a bed of rice in March or April and the young shoots are transplanted to the paddy field in May or June. October is usually the harvest time. In Formosa, the paddy plants cultivated by this method are growing at the time intervenning between the usual first and second crops (of the Double-crop Method). If the paddy plants are cultivated in this way in a field placed between those cultivated by Double-crop Method, the moths gather in this field when the first crop of the Double-crop Method fields is reaped. This is probably the only reason that the fields cultivated by this method are very often seriously injured by "Itten-O-Meiga".

In Japan, "Itten-O-Meiga" increases with the growth of the paddy and the insects emerge twice or thrice in a year on the paddy plants cultivated by this method. The effect of this method of rice cultivation on the growth of "Itten-O-Meiga" cannot be compared with others because no other method is used. There is of course the cultivation of upland rice, but this Pyralid is not known to attack it.

In short, this method in Formosa is sometimes favourable to the growth of the larvae of the third generation.

**e. Single-first-crop Method.**

In this method a common kind of first crop is cultivated by the same method as that employed in Double-crop Method, and the harvest time comes in June and July. After this fields are kept free from cultivation of a second crop. This method is usually practised at Shiiho (Giran-Cho). In this locality the irrigation water is always so much in volume that the second crop cannot be cultivated, this is due to the geographical position. It is well-known that "Itten-O-Meiga" is usually very scarce in this district. Although "Itten-O-Meiga" lives on the paddy until the harvest time of the first crops, after this it cannot find a host-plant. Necessarily the

moths which emerge during this time are forced to move to the nearest paddy fields. If such moths are able to reach a rice field successfully, they deposit their eggs and the larvae of the next generation will appear, but this rarely happens. In early Spring, when the paddy plants are cultivated in this locality, "Itten-O-Meiga" will, of course, occur in small numbers, and begin to grow again; this is perhaps repeated every year.

These facts probably cause the condition already stated.

### f. Single-second-crop Method.

In the districts of both Kagi-Cho and Tainan-Cho, there are many fields where flooding can only be carried out by means of rainfall, though there is some artificial irrigation system. In this climate, where the temperature changes but little throughout the year, seed time and harvest are, by means of irrigation, very much at the will of the husbandman, who therefore generally fixes his seed time according to the average conditions of rainfall in his particular district. In some districts the seed time is arranged for April, while in other districts it is in August, and in many districts sowing occurs at widely differing periods between April and August. The replantation time cannot generally be fixed by the farmer, in many different districts therefore the harvest time varies correspondingly with the replantation times. By means of such conditions in the lower half of Formosa, paddy plants in every stage are found throughout almost the whole of the year. In such cultivation the seeds of the second crop (in Double-crop Method) are used, and cultivated only once in the year.

In these districts the outbreak of the insect always occurs in great abundance. This fact may be due to the following reasons — The moths always gather to oviposit on the living paddy plants which are most suitable to them, and the larvae grow up safely in the stems of such paddy. Although the paddy plants are reaped, their stumps always stand unburied by irrigation or ploughing, as



the preparation of the field is not practised until the following Spring when the hibernated insects emerge. Therefore the larvae or pupae living in such stubble can mature perfectly and emerge for the following generation.

In short, this method must be highly favourable to the increase of "Itten-O-Meiga", but not absolutely, and sometimes not better than Mixed Method for them.

### g. Open-sowing Method.

This method is practised in some localities in Ako-Cho and the Prefecture of Hozan, where there is no irrigation system. During June and July these districts have their rainy season, and some lands where there are no irrigation or draining canals are flooded by the rainfall. At such a time such lands are immediately prepared for paddy cultivation, ploughing, harrowing, etc. being done, and certain kinds of paddy seeds soaked for one day are sowed on them. Afterwards sprouting begins, the young plants grow up, and the paddy is reaped at the harvest time of the usual second crops.

It is annually observed that in these districts, the outbreak of "Itten-O-Meiga" is practically similar to those occurring on ordinary second crop fields, but always rather less. In certain fields, lying near these lands, and which are cultivated by Double-crop Method, the attack of this insect is usually greater, on the first crop, than it is in other fields of the kind.

In short, the paddy fields planted according to this method are slightly attacked by "Itten-O-Meiga" according as they are distant from the usual rice fields. In other cases the attack is probably similar to that of the usual second crop fields.

### h. Aqua-terrestrial Method.

This method is rather peculiar. The paddy seeds, which are an intermediate kind between aquatic and upland rices, are sown in rows on the land. Afterwards, if it rains and the field is flooded, the young plant is cultivated like an ordinary, if not, it is treated

as an upland paddy. This cultivation begins in April and ends in October.

It is practised only in a few localities in Kagi-Cho, and there it is found that "Itten-O-Meiga" does not occur abundantly. It is observed that if it is cultivated as an aquatic paddy, the attacks of "Itten-O-Meiga" are nearly similar to those upon paddy cultivated according to the Summer Method, otherwise there is hardly any attack.

These facts are probably to be attributed to the fact that the stems are so small and so hard that the larvae cannot bore or live in them.

As an addition to Section 7 I will add a few notes on the cultivation of upland paddy. This kind of rice plant, as a rule, is hardly attacked by "Itten-O-Meiga", in Formosa. Although in other countries they may attack it, I am unable to state much with regard to this, because, according to several observations made in the laboratory, it is well ascertained that the larvae cannot bore through the stems of the upland rice.

If we could be content to live only on upland paddy, the fields could be occupied with this rice plant, and might be free from "Itten-O-Meiga". But we cannot do this, and are indeed to cultivate the best kind of aquatic paddy, because it is very nice; in fact, there is no comparison between them. This is, of course, "Double-crop Method" in Formosa.

To conclude, if, at the time between the first and second crop fields, no paddy plants cultivated by any other method were allowed to stand, the damage done by the insect would probably be decreased.

## 8. Effect of Reaping.

The method of reaping is probably the same (or similar) in all countries and districts, but the height at which it is reaped from



the surface of the soil varies according to the customs of the farmers, in each district. This difference has a great effect on the emergence of the next generation; namely, the larvae (or pupae) if left in the stubble can mature and emerge; if they are reaped with the stems, they cannot pupate or emerge, in Formosa; and in Japan, very rarely. Observation, were made for three years, to ascertain the percentage of this insect remaining in the reaped stems which emerged. The appended table summarizes the results:—

**Table XXI.** Effect of paddy-reaping on larvae.

| Locality | Date | Number of stems which observed. | Number of injured stems which observed. | Number of moths which emerged. | Number of larvae dying in stems. | Number of pupae dying in stems. | Total number of insects in stems. | Percentage of moths which emerged. | Duration of drying the stems. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | % | |
| Taihoku | 2.vii-09 | 1119 | ? | 19 | 2 | 12 | 33 | 57.58 | 3 days |
| Taichiu | 16.vi-09 | 553 | 170 | 7 | 4 | 3 | 14 | 50.00 | 3 " |
| Hozan | 20.vi-09 | 311 | 92 | 2 | 3 | 5 | 10 | 20.00 | 1 " |
| Taihoku | 8.xi-09 | 1736 | ? | 0 | 46 | 1 | 47 | 0 | 3 " |
| Taichiu | 20.xi-09 | 654 | 182 | 0 | 84 | 0 | 84 | 0 | 3 " |
| Hozan | 18.xi-09 | 742 | 300 | 0 | 28 | 0 | 28 | 0 | 1 " |
| Taihoku | 8.viii-10 | 474 | 241 | 0 | 12 | 4 | 16 | 0 | 3 " |
| Taichiu | 8.viii-10 | 1216 | 482 | 2 | 9 | 2 | 13 | 15.40 | 0 |
| Taichiu | 27.vii-10 | 935 | 397 | 0 | 0 | 0 | 0 | 0 | 3 " |
| Hozan | 28.vi-10 | 742 | 254 | 6 | 18 | 2 | 26 | 23.00 | 1 " |
| Taihoku | 7.xi-10 | 582 | 132 | 0 | 9 | 0 | 9 | 0 | 6 " |
| Taichiu | 19.xi-10 | 735 | 215 | 2 | 6 | 1 | 9 | 22.20 | 0 |
| do. | 21.xi-10 | 743 | 227 | 0 | 0 | 0 | 0 | 0 | 3 " |
| Hozan | 8.xi-10 | 863 | 113 | 0 | 15 | 0 | 15 | 0 | 1 " |
| Taihoku | 3.vii-11 | 564 | 160 | 0 | 9 | 0 | 9 | 0 | 4 " |
| Taichiu | 13.vi-11 | 920 | 294 | 3 | 0 | 0 | 3 | 100.00 | 0 |
| do. | 13.vi-11 | 1110 | 324 | 2 | 1 | 1 | 5 | 50.00 | 5 " |
| Hozan | 15.vi-11 | 103 | 94 | 8 | 18 | 1 | 37 | 32.20 | 1 " |
| Taihoku | 30.x-11 | 499 | 148 | 0 | 3 | 0 | 3 | 0 | 0 |
| do. | do. | 604 | 168 | 0 | 5 | 0 | 5 | 0 | 6 " |
| Taichiu | 10.xi-11 | 815 | 110 | 2 | 2 | 0 | 4 | 50.00 | 0 |
| do. | 10.xi-11 | 825 | 108 | 0 | 3 | 0 | 3 | 0 | 5 " |
| Hozan | 3.xi-11 | 932 | 126 | 0 | 4 | 1 | 5 | 0 | 1 " |

In the observations the paddy plant was reaped at the level of the land, and dried (except the undried one) by the usual methods which are practised in each locality. After this the stems were immediately placed in a large breeding-cage and were examined after the replantation of the next crop. This table shows that the insects remaining in the reaped stems are almost always killed on account of the dryness of the stalks, but that they are sometimes able to emerge. In the latter case the insects had probably pupated and manured perfectly before the reaping.

Many researches were also tried to ascertain their position in the stems during the reaping time; namely, to determine the percentage remaining in the reaped stems, when the rice plant is reaped by the usual methods practised by husbandmen in each district. The following table summarizes the results :—

**Table XXII.** Position of the larvae in paddy stem, during the reaping period, in Formosa (1907-1913).

| Reaping time. | Locality | Number of insects which observed. | Number of insects at various heights from the root. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Root-1.2 in. | 1.2-2.4 | 2.4-3.6 | 3.6-4.8 | 4.8-6.0 | 6.0-7.2 | 7.2-8.4 | 8.4-9.6 | 9.6-10.8 | 10.8-1 ft. | Over 1 ft. |
| First Crop. | Ako | 35 | 11 | 9 | 5 | 1 | 0 | 2 | 0 | 3 | 0 | 0 | 4 |
| | Tainan | 34 | 5 | 7 | 4 | 3 | 3 | 2 | 0 | 0 | 1 | 0 | 9 |
| | Taichiu | 114 | 29 | 21 | 16 | 12 | 13 | 3 | 1 | 1 | 6 | 5 | 7 |
| | Taihoku | 16 | 0 | 1 | 0 | 2 | 0 | 0 | 2 | 3 | 0 | 1 | 7 |
| Second Crop. | Ako | 57 | 31 | 12 | 2 | 2 | 6 | 3 | 0 | 0 | 1 | 0 | 0 |
| | Tainan | 64 | 52 | 6 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | Taichiu | 140 | 109 | 16 | 2 | 7 | 4 | 2 | 0 | 0 | 0 | 0 | – |
| | Taihoku | 38 | 25 | 3 | 11 | 1 | 0 | 2 | 3 | 0 | 0 | 1 | |



In these researches the various kinds of paddy plant were observed and almost all the "Itten-O-Meiga" were larvae, except those on the first crop.

From the above table it is evident that "Itten-O-Meiga" lives in greater numbers, proportionally, towards the lower part of the stem.

In Formosa the rice plants are practically never reaped below six inches from the ground, therefore the larvae (or pupae) are almost all left in the stubble. This is probably one of the causes which leads annually to a greater outbreak of "Itten-O-Meiga" in Formosa than in Japan, where the paddy is usually reaped nearer the level of the ground.

## 9. Effect of the Preparation of the Fields after Reaping.

Although in Formosa there are few methods of preparation, they are practically all similar, but vary as to time. This has a great influence on the emergence of the next generation. After the reaping of the first crop the fields are immediately prepared for the second crop and left for a few days only, as if in an uncultivated condition, flooded. In this case it is evident that the larvae (or pupae) living in the stubble are killed on account of the ploughing, harrowing and irrigating. Under this section we shall only discuss the conditions found in the field after the reaping of the second crop. After reaping there will be found four different conditions; namely, untreated fields, flooded fields, ploughed fields, and ploughed and flooded fields.

During four years (1909-1912) many observations were made to discover the state of the larvae (or pupae) living in the stubble in the fields under these conditions. The results are summarized in the following table :—

**Table XXIII.** Condition of larvae living in stubble, Formosa.

| Date when examined. | Locality | First series | | | | Second series | | | | Third series | | | | Fourth series | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Condition of larvae living in stubble | | Condition of pupae living in stubble | | Condition of larvae living in stubble | | Condition of pupae living in stubble | | Condition of larvae living in stubble | | Condition of pupae living in stubble | | Condition of larvae living in stubble | | Condition of pupae living in stubble | |
| | | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. |
| | | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. |
| 30.xi. | 1909 | 14 | 0 | 0 | .. | 9 | 18.1 | 0 | .. | 6 | 46.2 | 0 | .. | 5 | 100.0 | 0 | .. |
| 17.xii. | 1909 | 0 | 0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 0 | 0 | .. |
| 5.i. | 1910 | 3 | 0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 33.3 | 0 | .. | 0 | 0 | 0 | .. |
| 20.i. | 1910 | 1 | 50.0 | 0 | .. | 0 | 50.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 0 | 0 | .. |
| 9.ii. | 1910 | 0 | 66.7 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 66.7 | 0 | .. | 0 | 0 | 0 | .. |
| 15.ii. | 1910 | 0 | 50.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 66.7 | 0 | .. | 0 | 0 | 0 | .. |
| 20.ii. | 1910 | 0 | 0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 0 | 0 | .. |
| 25.ii. | 1910 | 0 | 33.3 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 0 | 0 | .. |
| 2.iii. | 1910 | 1 | 33.3 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 0 | 0 | .. |
| 7.iii. | 1910 | 1 | 50.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 0 | 0 | .. |
| 12.iii. | 1910 | 0 | .. | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 0 | 0 | .. |
| 17.iii. | 1910 | 0 | 0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 0 | 0 | .. |
| 22.iii. | 1910 | 1 | 50.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 0 | 0 | .. |
| 27.iii. | 1910 | 2 | 33.3 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 100.0 | 0 | .. | 0 | 0 | 0 | .. |
| 5.xii. | 1909 | 10 | 9.9 | 1 | .. | 16 | 11.1 | 0 | .. | 2 | 28.6 | 0 | .. | 0 | 0 | 0 | .. |



| Date when examined. | Locality | First series | | | | Second series | | | | Third series | | | | Fourth series | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Condition of larvae living in stubble | | Condition of pupae living in stubble | | Condition of larvae living in stubble | | Condition of pupae living in stubble | | Condition of larvae living in stubble | | Condition of pupae living in stubble | | Condition of larvae living in stubble | | Condition of pupae living in stubble | |
| | | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. | Alive. | Dead. |
| | | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. | Number | Percentage of insects which died. |
| 18.xi. | 1909 | 79 | 1·3 | 0 | .. | 130 | 1.5·0 | 0 | .. | 93 | 0 | 0 | .. | 145 | 3 | 2·0 | .. |
| 4.xii. | 1909 | 74 | 1·3 | 0 | .. | 120 | 12·4 | 0 | .. | 47 | 41 | 0 | .. | 136 | 5 | 3·4 | .. |
| 18.xii. | 1909 | 90 | 5·3 | 0 | .. | 46 | 13 | 0 | .. | 61 | 52 | 0 | .. | 108 | 99·1 | 0 | .. |
| 2.i. | 1910 | 69 | 4·2 | 0 | .. | 59 | 6 | 0 | .. | 21 | 50 | 0 | .. | 75 | 98·7 | 0 | .. |
| 17.i. | 1910 | 84 | 4·5 | 0 | .. | 25 | 16·7 | 0 | .. | 11 | 47 | 0 | .. | 63 | 100.0 | 0 | .. |
| 1.ii. | 1910 | 50 | 9·1 | 0 | .. | 15 | 31·8 | 0 | .. | 12 | 76 | 0 | .. | 107 | 100.0 | 0 | .. |
| 16.ii. | 1910 | 22 | 1·9 | 0 | .. | 11 | 52·2 | 0 | .. | 4 | 61 | 0 | .. | 46 | 100.0 | 0 | .. |
| 30.xi. | 1910 | 29 | 0 | 0 | .. | 25 | 0 | 0 | .. | 22 | 0 | 0 | .. | 47 | 0 | 0 | .. |
| 5.xii. | 1910 | 23 | 0 | 0 | .. | 10 | 13 | 0 | .. | 44 | 0 | 0 | .. | 22 | 100.0 | 0 | .. |
| 10.xii. | 1910 | 29 | 0 | 0 | .. | 36 | 24 | 0 | .. | 30 | 0 | 0 | .. | 150 | 98.4 | 0 | .. |
| 15.xii. | 1910 | 28 | 0 | 0 | .. | 5 | 9 | 0 | .. | 15 | 0 | 0 | .. | 110 | 100.0 | 0 | .. |
| 20.xii. | 1910 | 16 | 0 | 0 | .. | 4 | 16 | 0 | .. | 21 | 0 | 0 | .. | 43 | 100.0 | 0 | .. |
| 25.xii. | 1910 | 12 | 0 | 0 | .. | 14 | 13 | 0 | .. | 22 | 0 | 0 | .. | 50 | 100.0 | 0 | .. |
| 30.xii. | 1910 | 11 | 0 | 0 | .. | 9 | 8 | 0 | .. | 44 | 0 | 0 | .. | 40 | 100.0 | 0 | .. |
| 4.i. | 1911 | 27 | 6.9 | 0 | .. | 9 | 4 | 0 | .. | 12 | 0 | 0 | .. | 0 | 0 | 0 | .. |
| 9.i. | 1911 | 25 | 0 | 0 | .. | 4 | 10 | 0 | .. | 10 | 0 | 0 | .. | 0 | 0 | 0 | .. |
| 14.i. | 1911 | 6 | 0 | 0 | .. | 11 | 8 | 0 | .. | 8 | 1 | 0 | .. | 0 | 0 | 0 | .. |
| 19.i. | 1911 | 7 | 12.5 | 0 | .. | 6 | 45·5 | 0 | .. | 5 | 28.6 | 0 | .. | 0 | 0 | 0 | .. |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23.iii. 1912 | 21 | 6 | 22·2 | 14 | 1 | 6·7 | 4 | 21 | 84·0 | 0 | 0 | .. | 15 | 3 | 16·7 | 5 | 2 | 28·6 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 25.i. 1911 | 19 | 0 | 0 | 0 | 0 | .. | 0 | 0 | 80·0 | 0 | 0 | .. | 12 | 3 | 6·7 | 0 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 2.ii. 1911 | 4 | 2 | 33·3 | 0 | 0 | .. | 3 | 16 | 84·2 | 0 | 0 | .. | 11 | 0 | 0 | 0 | 0 | .. | 0 | 0 | .. | 2 | 12 | 100.0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 7.ii. 1911 | 10 | 2 | 16·7 | 0 | 0 | .. | 0 | 11 | 100.0 | 0 | 0 | .. | 2 | 0 | 0 | 0 | 0 | .. | 0 | 0 | .. | 0 | 19 | 100.0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 12.ii. 1911 | 5 | 0 | 0 | 0 | 7 | 0 | 0 | 16 | 88·9 | 0 | 0 | .. | 3 | 3 | 50·0 | 0 | 0 | .. | 0 | 0 | .. | 0 | 14 | 100.0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 18.ii. 1911 | 3 | 0 | 0 | 5 | 0 | 0 | 0 | 18 | 100.0 | 0 | 0 | .. | 2 | 10 | 83·3 | 0 | 0 | .. | 0 | 0 | .. | 0 | 15 | 100.0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 25.ii. 1911 | 1 | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 93·3 | 0 | 0 | .. | 4 | 7 | 63·6 | 0 | 0 | .. | 0 | 0 | .. | 0 | 18 | 100.0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 27.iii. 1911 | 19 | 21 | 52·5 | 7 | 4 | 36·3 | 0 | 84 | 100.0 | 0 | 0 | .. | 6 | 33 | 84·6 | 0 | 0 | .. | 0 | 1 | 100.0 | 0 | 26 | 100.0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.xii. 1911 | 22 | 2 | 8·3 | 0 | 0 | .. | 25 | 1 | 3·8 | 0 | 0 | .. | 22 | 2 | 8·3 | 0 | 0 | .. | 25 | 1 | 3·8 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 10.xii. 1911 | 16 | 1 | 5·9 | 0 | 0 | .. | 34 | 11 | 24·4 | 0 | 0 | .. | 20 | 1 | 4·8 | 0 | 0 | .. | 12 | 14 | 53·8 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 15.xii. 1911 | 6 | 1 | 14·3 | 0 | 0 | .. | 16 | 35 | 68·6 | 0 | 0 | .. | 8 | 2 | 20·0 | 0 | 0 | .. | 9 | 56 | 86·2 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 20.xii. 1911 | 13 | 2 | 13·3 | 0 | 0 | .. | 51 | 33 | 44·6 | 0 | 0 | .. | 29 | 1 | 3·3 | 0 | 0 | .. | 5 | 64 | 92·8 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 25.xii. 1911 | 23 | 1 | 4·2 | 0 | 0 | .. | 30 | 42 | 58·3 | 0 | 0 | .. | 46 | 2 | 4·2 | 0 | 0 | .. | 2 | 34 | 94·4 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 30.xii. 1911 | 14 | 5 | 26·3 | 0 | 0 | .. | 27 | 30 | 52·6 | 0 | 0 | .. | 18 | 4 | 18·2 | 0 | 0 | .. | 0 | 55 | 100.0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 4.i. 1912 | 28 | 4 | 12·5 | 0 | 0 | .. | 20 | 28 | 58·3 | 0 | 0 | .. | 21 | 2 | 8·7 | 0 | 0 | .. | 0 | 39 | 100.0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 9.i. 1912 | 13 | 5 | 27·8 | 0 | 0 | .. | 18 | 24 | 57·1 | 0 | 0 | .. | 23 | 3 | 11·5 | 0 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 14.i. 1912 | 9 | 4 | 30·8 | 0 | 0 | .. | 16 | 23 | 58·9 | 0 | 0 | .. | 11 | 2 | 15·4 | 0 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 19.i. 1912 | 18 | 2 | 10·0 | 1 | 0 | .. | 11 | 28 | 71·5 | 0 | 0 | .. | 21 | 1 | 4·5 | 0 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 24.i. 1912 | 22 | 1 | 4·3 | 15 | 0 | 0 | 9 | 27 | 75·0 | 0 | 0 | .. | 25 | 3 | 10·7 | 5 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 29.i. 1912 | 23 | 2 | 8·0 | 12 | 0 | 0 | 5 | 35 | 85·0 | 1 | 1 | 50·0 | 35 | 5 | 12·5 | 2 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 3.ii. 1912 | 52 | 5 | 8·8 | 5 | 0 | 0 | 7 | 24 | 77·4 | 0 | 0 | .. | 14 | 5 | 26·3 | 2 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 8.ii. 1912 | 67 | 5 | 6·9 | 5 | 0 | 0 | 5 | 31 | 86·1 | 2 | 0 | .. | 13 | 6 | 33·3 | 1 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 13.ii. 1912 | 32 | 5 | 13·5 | 18 | 1 | 0 | 8 | 23 | 74·2 | 1 | 2 | 66·7 | 8 | 3 | 27·3 | 2 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 18.ii. 1912 | 5 | 6 | 54·5 | 11 | 0 | 0 | 3 | 25 | 89·3 | 2 | 2 | 50·0 | 12 | 3 | 20·0 | 3 | 2 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 23.ii. 1912 | 21 | 6 | 22·2 | 14 | 1 | 6·7 | 4 | 21 | 84·0 | 0 | 0 | .. | 15 | 3 | 16·7 | 5 | 2 | 28·6 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |



| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24.ii. 1911 | 5 | 0 | 0 | 3 | 0 | 0 | 5 | 8 | 61·5 | 0 | 0 | .. | 6 | 0 | 2·4 | 0 | 0 | .. | 40 | 0 | 0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 29.i. 1911 | 4 | 1 | 20.0 | 0 | 0 | 0 | 3 | 8 | 72·7 | 0 | 0 | .. | 4 | 2 | 33·3 | 0 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 3.iii. 1911 | 3 | 0 | 0 | 0 | 0 | .. | 9 | 8 | 64·3 | 0 | 0 | .. | 2 | 8 | 80.0 | 0 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 8.iii. 1911 | 7 | 0 | 0 | 1 | 0 | 0 | 5 | 20 | 85·3 | 0 | 0 | .. | 30 | 0 | 0 | 0 | 0 | .. | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 13.iii. 1911 | 2 | 0 | 0 | 5 | 0 | 0 | 3 | 22 | 88.0 | 1 | 1 | 50.0 | 45 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 18.iii. 1911 | 1 | 0 | 0 | 6 | 0 | 0 | 2 | 17 | 89·5 | 0 | 3 | 100.0 | 36 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 23.iii. 1911 | 14 | 0 | 0 | 6 | 0 | 0 | 0 | 10 | 100.0 | 1 | 2 | 66·7 | 12 | 0 | 20.0 | 5 | 0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 28.iii. 1911 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 13 | 100.0 | 1 | 1 | 50.0 | 12 | 3 | 20.0 | 40 | 0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 6.iii. 1911 | 0 | 1 | 100.0 | 5 | 0 | 0 | 0 | 17 | 100.0 | 2 | 1 | 33·3 | 10 | 2 | 16·7 | 38 | 0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.xi. 1910 | 40 | 0 | 0 | 0 | 0 | .. | 23 | 8 | 25·8 | 0 | 0 | .. | 22 | 2 | 8·3 | 0 | 0 | .. | 40 | 0 | 0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 19.xi. 1910 | 25 | 1 | 7·7 | 0 | 0 | .. | 20 | 4 | 16·7 | 0 | 0 | .. | 18 | 4 | 18.0 | 0 | 0 | .. | 22 | 10 | 31·2 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 24.xi. 1910 | 21 | 1 | 45.0 | 0 | 0 | .. | 25 | 5 | 16·7 | 0 | 0 | .. | 23 | 7 | 23·3 | 0 | 0 | .. | 20 | 13 | 39·4 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 29.xi. 1910 | 26 | 2 | 7·1 | 0 | 0 | .. | 22 | 3 | 12.0 | 0 | 0 | .. | 18 | 0 | 0 | 0 | 0 | .. | 19 | 11 | 36·7 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 4.xii. 1910 | 23 | 0 | 0 | 0 | 0 | .. | 15 | 7 | 31·8 | 0 | 0 | .. | 19 | 4 | 17·4 | 0 | 0 | .. | 17 | 13 | 43·4 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 9.xii. 1910 | 29 | 3 | 9·3 | 0 | 0 | .. | 18 | 5 | 21·7 | 0 | 0 | .. | 23 | 2 | 8.0 | 0 | 0 | .. | 20 | 14 | 41·2 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 14.xii. 1910 | 22 | 0 | 0 | 0 | 0 | .. | 15 | 7 | 31·8 | 0 | 0 | .. | 19 | 4 | 17·4 | 0 | 0 | .. | 17 | 13 | 43·4 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 19.xii. 1910 | 17 | 0 | 0 | 0 | 0 | .. | 20 | 9 | 31.0 | 0 | 0 | .. | 17 | 3 | 15.0 | 0 | 0 | .. | 2 | 23 | 92.0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 24.xii. 1910 | 22 | 0 | 0 | 0 | 0 | .. | 25 | 0 | 0 | 0 | 0 | .. | 24 | 3 | 11.1 | 0 | 0 | .. | 1 | 24 | 96.0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 29.xii. 1910 | 25 | 4 | 13.8 | 0 | 0 | .. | 28 | 3 | 9·7 | 0 | 0 | .. | 21 | 2 | 8·7 | 0 | 0 | .. | 0 | 23 | 100.0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 4.i. 1911 | 21 | 3 | 12.5 | 2 | 0 | 0 | 27 | 5 | 15·6 | 0 | 0 | .. | 19 | 4 | 17·4 | 0 | 0 | .. | 0 | 27 | 100.0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 8.i. 1911 | 23 | 2 | 8.0 | 3 | 0 | 0 | 28 | 16 | 47·1 | 0 | 0 | .. | 29 | 3 | 9·4 | 0 | 0 | .. | 0 | 25 | 100.0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 12.i. 1911 | 13 | 7 | 35.0 | 0 | 0 | 0 | 31 | 20 | 39·2 | 0 | 0 | .. | 19 | 4 | 17·4 | 0 | 0 | .. | 0 | 29 | 100.0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 18.i. 1911 | 20 | 0 | 0 | 0 | 0 | 0 | 19 | 25 | 54·8 | 0 | 0 | .. | 23 | 16 | 41·0 | 0 | 0 | .. | 0 | 18 | 100.0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |
| 23.i. 1911 | 26 | 0 | 0 | 0 | 0 | 0 | 5 | 16 | 76·2 | 0 | 0 | .. | 22 | 14 | 38·9 | 0 | 0 | .. | 0 | 6 | 100.0 | 0 | 0 | 0 | .. | 0 | 0 | 0 | .. | 0 | 0 |

ЗИМОЈАК

a). If the paddy stubble is left in the fields after reaping, a certain proportion of the larvae mature and pupate; but many dead larvae or pupae are found. This condition is the most usual in nature.

b). If the paddy stubble is submerged the percentage of dead larvae is greater than it is in the first series and increases correspondingly with the duration of the submergence. This is very rare in nature.

c). If the field is ploughed the larvae are almost in the same condition as those in the first series, but the percentage of the larvae which die is, roughly speaking, greater. This condition of the field is found in many localities where green manure plants and vegetables are grown as a rule.

d). If the field is ploughed and irrigated the larvae or pupae are much in the condition found in the second series, and the percentage which die is extremely large, and almost all perish by the preparation time for the replantation of the next paddy. Fields standing in such a condition are sometimes found in nature.

In these observations the dead larvae or pupae were almost all found in decayed stubble and the live ones in the somewhat green stumps, although they were entirely submerged. In addition to these, during three years 1909-1911 many observations were made to ascertain if "Itten-O-Meiga" could emerge when the paddy stubble was buried under the soil. In the observations three experimental fields were first enclosed and covered separately with large breeding cages, and then a number of stumps which were seriously attacked by "Itten-O-Meiga" were buried under the soil in each breeding cage, respectively at 1-2(First Series), 2-4(Second Series), 3-6(Third Series) inches in depth. After this, on each date ten stumps were taken out of each cage and were examined. The appended table summarizes the results:—



| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 28.ii. 1912 | 35 | 8 | 18.6 | 18 | 2 | 10.0 | 2 | 26 | 92.8 | 0 | 2 | 100.0 | 12 | 8 | 40.0 | 9 | 1 | 10.0 | 0 | 0 | .. | 0 | 0 | .. |
| | 4.iii. 1912 | 31 | 1 | 3.1 | 13 | 3 | 18.8 | 0 | 16 | 100.0 | 0 | 3 | 100.0 | 11 | 6 | 35.3 | 3 | 1 | 25.0 | 0 | 0 | .. | 0 | 0 | .. |
| Hozan | 7.xii. 1911 | 13 | 0 | 0 | 0 | 0 | .. | 6 | 1 | 14.3 | 0 | 0 | .. | 16 | 0 | 0 | 0 | 0 | .. | 2 | 7 | 77.8 | 0 | 0 | .. |
| | 12.xii. 1911 | 8 | 1 | 11.1 | 0 | 0 | .. | 9 | 3 | 25.0 | 0 | 0 | .. | 13 | 1 | 7.1 | 0 | 0 | .. | 3 | 4 | 57.1 | 0 | 0 | .. |
| | 17.xii. 1911 | 9 | 2 | 18.2 | 0 | 0 | .. | 2 | 3 | 60.0 | 0 | 0 | .. | 8 | 1 | 11.1 | 0 | 0 | .. | 2 | 5 | 41.4 | 0 | 0 | .. |
| | 22.xii. 1911 | 12 | 3 | 20.0 | 0 | 0 | .. | 13 | 12 | 48.0 | 0 | 0 | .. | 7 | 2 | 22.2 | 0 | 0 | .. | 4 | 4 | 50.0 | 0 | 0 | .. |
| | 5.i. 1912 | 10 | 5 | 33.3 | 0 | 0 | .. | 0 | 15 | 100.0 | 0 | 0 | .. | 1 | 4 | 80.0 | 0 | 0 | .. | 0 | 6 | 100.0 | 0 | 0 | .. |
| | 12.i. 1912 | 8 | 1 | 11.1 | 0 | 0 | .. | 1 | 5 | 83.3 | 0 | 0 | .. | 6 | 0 | 0 | 0 | 0 | .. | 3 | 7 | 70.0 | 0 | 0 | .. |
| | 18.i. 1912 | 17 | 3 | 15.0 | 0 | 0 | .. | 0 | 7 | 100.0 | 0 | 0 | .. | 13 | 4 | 23.5 | 0 | 0 | .. | 2 | 14 | 87.5 | 0 | 0 | .. |
| | 22.i. 1912 | 12 | 2 | 14.3 | 3 | 0 | 0 | 4 | 5 | 55.6 | 0 | 0 | .. | 9 | 4 | 30.8 | 1 | 0 | 0 | 1 | 16 | 94.1 | 0 | 0 | .. |
| | 27.i. 1912 | 10 | 1 | 9.9 | 0 | 0 | .. | 3 | 7 | 70.0 | 0 | 0 | .. | 10 | 2 | 16.7 | 0 | 0 | .. | 0 | 13 | 100.0 | 0 | 0 | .. |
| | 4.ii. 1912 | 14 | 2 | 12.5 | 3 | 0 | 0 | 5 | 19 | 79.2 | 0 | 1 | 100.0 | 13 | 7 | 35.0 | 2 | 0 | 0 | 0 | 9 | 100.0 | 0 | 0 | .. |

Note. The *first series* were observed in the untreated fields after reaping.

The *second series* in the flooded fields where the paddy stubble was entirely submerged the irrigation water.

The *third series* in the ploughed fields where the paddy stubble was not entirely buried.

The *fourth series* in the ploughed and flooded fields where the paddy stubble was entirely submerged and mostly buried.

These observations were practised immediately after reaping, in seriously damaged fields, and fifty paddy stumps were examined in each series on the above dates.

Table xxiii shows the following facts:—

Table XXIV. Effect of burying stubble, Formosa.

| Locality | Duration of burying paddy stubble. | First series. | | | | | Second series. | | | | | Third series. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of moths which emerged. | Number of moths dying in soil. | Condition of insects in stubble. | | | Number of moths which emerged. | Number of moths dying in soil. | Condition of insects in stubble. | | | Number of moths which emerged. | Number of moths dying in soil. | Condition of insects in stubble. | | |
| | | | | Alive. Number. | Dead. Number. | Percentage of insects which died. | | | Alive. Number. | Dead. Number. | Percentage of insects which died. | | | Alive. Number. | Dead. Number. | Percentage of insects which died. |
| Taihoku | 15 | 0 | 0 | 206 | 4 | 1.9 | 0 | 0 | 223 | 7 | 3.0 | 0 | 0 | 227 | 7 | 2.9 |
| | 30 | 0 | 0 | 147 | 19 | 11.4 | 0 | 0 | 162 | 28 | 14.7 | 0 | 0 | 127 | 16 | 11.2 |
| | 45 | 0 | 0 | 85 | 29 | 25.4 | 0 | 0 | 91 | 37 | 28.7 | 0 | 0 | 83 | 47 | 36.2 |
| | 60 | 0 | 0 | 32 | 64 | 66.7 | 0 | 0 | 34 | 69 | 66.9 | 0 | 0 | 27 | 57 | 67.9 |
| | 75 | 0 | 0 | 6 | 66 | 91.7 | 0 | 0 | 13 | 71 | 84.5 | 0 | 0 | 8 | 56 | 87.5 |
| | 90 | 0 | 0 | 11 | 54 | 83.1 | 0 | 0 | 3 | 61 | 95.3 | 0 | 0 | 2 | 60 | 96.8 |
| | 105 | 0 | 0 | 7 | 78 | 91.8 | 0 | 0 | 4 | 63 | 94.0 | 0 | 0 | 3 | 66 | 95.7 |
| | 120 | 0 | 0 | 2 | 28 | 93.3 | 0 | 0 | 0 | 35 | 100.0 | 0 | 0 | 2 | 36 | 94.7 |
| Taihoku | 15 | 0 | 0 | 184 | 6 | 3.2 | 0 | 0 | 157 | 4 | 2.5 | 0 | 0 | 188 | 3 | 1.6 |
| | 39 | 0 | 0 | 176 | 16 | 8.3 | 0 | 0 | 151 | 13 | 7.9 | 0 | 0 | 158 | 14 | 8.1 |
| | 45 | 0 | 0 | 310 | 9 | 2.8 | 0 | 0 | 170 | 4 | 2.3 | 0 | 0 | 160 | 11 | 6.4 |
| | 60 | 0 | 0 | 123 | 20 | 13.9 | 0 | 0 | 138 | 31 | 1.9 | 0 | 0 | 137 | 17 | 11.0 |
| | 75 | 0 | 0 | 94 | 28 | 22.9 | 0 | 0 | 87 | 26 | 23.0 | 0 | 0 | 81 | 37 | 31.4 |
| | 90 | 0 | 0 | 94 | 46 | 32.9 | 0 | 0 | 70 | 40 | 36.4 | 0 | 0 | 68 | 47 | 40.0 |
| | 105 | 7 | 0 | 24 | 47 | 66.2 | 2 | 0 | 38 | 47 | 55.3 | 0 | 0 | 28 | 57 | 67.1 |
| Hozan | 10 | 0 | 0 | 45 | 1 | 2.2 | 0 | 0 | 52 | 2 | 7.4 | 0 | 0 | 76 | 7 | 8.5 |
| | 20 | 0 | 0 | 18 | 2 | 10.0 | 0 | 0 | 11 | 2 | 15.4 | 0 | 0 | 34 | 6 | 15.0 |
| | 30 | 0 | 0 | 93 | 14 | 13.1 | 0 | 0 | 112 | 43 | 27.7 | 0 | 0 | 103 | 38 | 26.9 |
| | 40 | 0 | 0 | 60 | 40 | 40.0 | 0 | 0 | 47 | 48 | 50.5 | 0 | 0 | 70 | 45 | 39.1 |
| | 50 | 0 | 0 | 43 | 37 | 46.3 | 0 | 2 | 65 | 46 | 41.4 | 0 | 0 | 59 | 50 | 49.9 |
| | 60 | 0 | 0 | 45 | 24 | 34.8 | 0 | 0 | 44 | 36 | 45.0 | 0 | 0 | 43 | 50 | 53.8 |
| | 70 | 1 | 0 | 43 | 48 | 52.7 | 0 | 0 | 40 | 24 | 37.5 | 0 | 0 | 27 | 29 | 51.8 |
| | 80 | 2 | 1 | 71 | 33 | 31.7 | 0 | 0 | 70 | 53 | 43.1 | 0 | 0 | 45 | 44 | 49.4 |
| | 90 | 1 | 0 | 15 | 20 | 57.1 | 1 | 1 | 20 | 21 | 51.2 | 0 | 0 | 10 | 46 | 82.1 |
| | 100 | 3 | 4 | 0 | 34 | 100.0 | 0 | 2 | 1 | 62 | 98.5 | 0 | 0 | 0 | 71 | 100.0 |

This table shows that the larvae (or pupae) almost all die if they are buried under the soil; that the pupating periods are later



than the usual time if they are able to pupate at all; and that they cannot emerge at all if they are buried over 3.6 inches deep.

## 10. Effect of Moisture and Dryness of the Land.

The moisture and dryness of the land have a great effect on the hibernating larvae as has been stated in section 9 and will also be stated in section 11. In nature it is very often observed that the hibernating larvae are killed in large numbers when extreme moisture and dryness happen alternately in the field. This is due to decaying of the paddy stubble.

During the growing period of the rice plant the larvae are very rarely killed on account of dryness and moisture of the land, but during the rainy season the dead larvae are usually found in the stems. This fact as chiefly due to an indirect cause; namely, during this season *Gordius sp.* occurs abundantly and attacks the larvae.

In short, dryness and moisture of the land during the Winter time have chiefly an indirect influence upon the death of the larvae.

## 11. Relation to the Kinds of Soil.

It is not actually known that "Itten-O-Meiga" occurs especially abundantly on paddy plants which grow in one particular kind of soil; but it seems as if in clayey land its occurrence is generally abundant, especially in Japan. According to my observations, in Formosa it is evident that the kinds of soil, combined with the moisture and dryness, have a relation to the death of the hibernating larvae.

a). *Sandy soil.* In Formosa this only occurs in seashore districts and as a rule the occurrence of "Itten-O-Meiga" in this districts is less than in others. During the Winter the northern parts have the rainy season, and the southern parts the dry season. In such districts the hibernating larvae are able to mature in comparative safety, and to pupate, in the northern parts but not in the southern. This is probably due to the dryness of the land. The withering of the paddy stubble has a close relation with the dryness of the sandy soil,

consequently, the hibernating larvae die in large numbers. It has also been ascertained by several experiments in the laboratory that in extremely moist sandy soil the stubble can remain in a living state for a long time, and that the larvae mature perfectly.

In short, sandy soil is not favourable for the hibernating of the larvae, in mostly parts of Formosa.

b). *Clay soil.* Many of the rice fields in Formosa lie on clay soil. In such field the percentage of hibernating larvae which die is generally less than it is in sandy soil, especially where this is dry. It is evident, from many researches in field, that in an extremely moist clay soil the paddy stumps remain in a living state until the time of preparation for the next cultivation, and that the hibernating larvae are in the larval state for a much longer time than usual; and that in a moderately moist clay soil they are under very favourable conditions.

In short, clay soil fields are most suitable for the hibernating larvae.

c). *Clay and sandy soil.* Practically, in the case of both moisture and dryness, the percentage of hibernating larvae dying is less than it is sandy soil. Although it is still unknown if it is more or less than on clayey land, this is probably determined by the proportion of the soil mixture; namely, if sand is mixed in large quantities the hibernating larvae probably are subject to the same influences as those on sandy soil, and if the clay preponderates over the sand, the influences are similar to those found in clayey soil.

In conclusion, the hibernating larvae living on clay soil enjoy the most suitable conditions, but in sandy soil the worst conditions are present. The other larvae (not hibernating) have not probably an intimate relation with the kind of soil on which they live.

## E. Choice of Foods.

Although it is quite evident that their food is rice plant and that the larvae feed on the tissue of the stem or, very rarely, on the chlorophyll of the leaf, it has not been ascertained if they can feed



on the withered stems as do the larvae of *Chilo simplex*.

The opinion is held by many planters and a few entomologists that the larvae, when reaped with the stems, feed on the withered tissues. In Formosa, a few observations were made during 1911; namely, after the reaping of the first crops, the larvae (Stage III and IV) were fed on both the growing paddy stems and the withered stems, in the labortory. In the observation the withered stems were well damped and placed in flooded pots.

The following table summarizes the results:—

**Table XXV.** Observations on the larvae living in both the growing stems and the withered stems, in Formosa.

| Stage of larvae | Condition of paddy plants. | Number of larvae | Number of living larvae after 10 days | Number of dead larvae during 10 days | Observations on the larvae living after ten days. |
|---|---|---|---|---|---|
| III | growing. | 5 | 5 | 0 | All developed perfectly and reached Stage IV; 5 stems injured. |
| do. | do. | do. | do. | 0 | do. |
| do. | do. | do. | do. | 0 | do. |
| do. | do. | do. | do. | 0 | Four of them developed and reached Stage IV, but one weakened and remained in Stage III. |
| IV | do. | do. | do. | 0 | Four of them developed and reached Stage V; 5 stems injured. |
| do. | do. | do. | do. | 0 | All devoloped and reached Stage V; 6 stems injured. |
| do. | do. | do. | do. | 0 | All developed and reached Stage V; 5 stems injured. |
| do. | do. | do. | do. | 0 | do. |
| III | withered | 5 | 4 | 1 | Three of them reached Stage IV, one nearly died. Five stems were not injured and entrance holes were bored in several places. |
| do. | do. | do. | 1 | 4 | In the body many transverse wrinkles were visible and they could not move; one stem slightly injured inside. |
| do. | do. | do. | 3 | 2 | All were on the point of death. All stems uninjured inside. |
| do. | do. | do. | 1 | 4 | Was removing with the temporary case; all stems uninjured, but one of them cut off at intermediate position. |

| | | | | | |
|---|---|---|---|---|---|
| IV | do. | do. | 1 | 4 | Weakened and on the point of death; all stems not eaten. |
| do. | do. | do. | 2 | 3 | Were removing with the temporary case, two stems cut off and others not injured. |
| do. | do. | do. | 5 | 0 | Were removing with the temporary case; 5 stems cut off at intermediate portion of stem. |
| do. | do. | do. | 1 | 4 | Reached Stage V, but extremely wasted; all stems uninjured. |

This table shows that the larvae, when reared on the withered stems, remove, making the temporary case; that they do not bore through the stem although they try to do so, notwithstanding that the paddy is not living. During the season of the second crops, such observations were again tried, but the results were similar.

In Japan, it is known, according to an observation of Mr. K. Nakagawa#, that the larvae do not feed on the withered paddy.

In short, the larvae of "Itten-O-Meiga" feed only on growing paddy plants.

### F. Amount of Injury on Paddy Plant of Different Period.

The characteristic habits of the larvae, as stated already, are slightly different at each stage of their existence. The amount of injury, which has effect on the yields, is utterly different at each growing period of the rice plant and must be considered separately.

#### i. On the young shoot growing in the bed.

In young paddy still growing in the bed, the newly hatched larvae seek out the tender unrolled leaves near the base of the opening portion. Here they bore through rolled-up leaves, making a very small transverse burrow. As soon as they reach the centre of the rolled-up leaves, they go down towards the root, boring and feeding on the central portion. Later, the tip of the injured plant withers, and becomes bleached. This is called by our people "Shingare". Although a young shoot of this kind is entirely injured at its growing point, a new bud comes up, usually from the root.

# see the Report of the Agr. Expt. Stat. Nishigahara. vol. XXXI.



The young shoot has only a growing point without a stem and does not divide into several shoots like the large paddy plants but its root is very strong and a new shoot grows whenever the old growing point has been killed. The larvae, as a rule cannot grow up fully on account of the plant being so small that they cannot remain in it. After the larvae have reached the lower portion of the plant, they are compelled to remove to another. Such larvae wander about to seek out larger plants, but no larger plants are to be found, and at last they die without home or are killed by natural enemies. Although one larva injures at least one young shoot, the latter is not entirely killed, and enough remains for replantation. Large larvae cannot usually be reared entirely on the young shoots.

In Japan it is noted by Mr. K. Nakagawa that the larvae cannot live on the young shoots cultivated in the bed; that they are very rarely found in the young shoots (which are larger than others) growing at the margins in the bed; and that their injuries are very slight.

In short, the injuries in the bed of paddy have no effect on the yields, and the larvae cannot develop on the young shoots.

#### 2. On the Paddy plants growing in the rice field.

The injury on the large plant is different in every stage of the growth and must be considered separately.

(a). *Before the ears grow in the rolled-up leaves.*

The larvae bore through the rolled-up leaves into the stems which grow in them, but such injured stems cannot usually be observed from the outside. One larva can injure two or three stems during this period, but in Formosa such injured stems very often recuperate by growing new stems from the lower portion of the injured one. In Japan, however, this does not occur.

An observation was made to ascertain the amount of injury to the second crop. In the observation, twenty injured paddy plants were marked with labels during this period, and were examined at the reaping time. The appended table summarizes

Table shows as follows :—

Although in 28.7 per cent of the number of the ear-bearing stems the injury occurs before the ears grow, 37.6 per cent of them are able to recuperate before the reaping time. But all the stems so injured are not able to grow perfect ears ; namely, 8.9 per cent of them stand without ears.

In short, in over 38 per cent of the stems injured new stems will perfectly develop before the reaping time.

b. *Before the shooting period, when the ears grow in the rolled-up leaves.*

During this period if the paddy stems are injured they come up having "white ears", and such stems cannot possibly recuperate. Although sometimes new stems grow up at the lower node of the injured stems, they do not reach the stage at which the ears grow.

An observation was made to ascertain the amount of injury at Taichiu, Formosa, in the same manner as stated in section a. The results were as follows :—

**Table XXVII.** Amount of injury before shooting period, Taichiu, 1913.

| Series | Plants injured befor shooting period. | | | | | | | Plants uninjured before shooting period. | |
|---|---|---|---|---|---|---|---|---|---|
| | Investigation at time when injured. | | | Investigation at reaping time. | | | | Investigation before shooting time. | Investigation at reaping time. |
| | Number of uninjured stems | Nnmber of injured stems | Total number of stems | Number of uninjured stems | Number of white ears | Number of young stems | Total number of stems | Number of uninjured stems | Number of uninjured stems |
| I | 17 | 1 | 18 | 17 | 1 | 0 | 18 | 20 | 19 |
| II | 21 | 1 | 22 | 20 | 2 | 0 | 22 | 19 | 19 |
| III | 17 | 1 | 18 | 17 | 1 | 0 | 18 | 18 | 16 |
| IV | 19 | 1 | 20 | 19 | 1 | 0 | 20 | 18 | 18 |



the results :—

**Table XXVI.** Amount of the injury on young paddy, Taichiu, 1913.

| Series | Injured plants before the ears grow in the rolled-up leaves. | | | | | | | Uninjured plants before the ears grow in the rolled-up leaves. | |
|---|---|---|---|---|---|---|---|---|---|
| | Investigation at time when injured. | | | Investigation at reaping time. | | | | Investigation before the ears grow. | Investigation at reaping time. |
| | Number of uninjured stems | Number of injured stems | Total Number of stems | Number of uninjured stems | Number of injured stems | Number of young stems | Total Number of stems | Number of uninjured stems | Number of uninjured stems |
| I | 9 | 1 | 10 | 10 | 0 | 0 | 10 | 17 | 17 |
| II | 22 | 1 | 23 | 16 | 0 | 0 | 16 | 18 | 18 |
| III | 14 | 2 | 16 | 15 | 0 | 0 | 15 | 20 | 19 |
| IV | 9 | 12 | 21 | 15 | 0 | 0 | 15 | 20 | 18 |
| V | 11 | 7 | 18 | 15 | 0 | 0 | 15 | 23 | 19 |
| VI | 7 | 12 | 19 | 16 | 0 | 0 | 16 | 18 | 15 |
| VII | 9 | 7 | 16 | 14 | 0 | 0 | 14 | 24 | 20 |
| VIII | 11 | 10 | 21 | 21 | 0 | 0 | 21 | 15 | 15 |
| IX | 5 | 10 | 15 | 13 | 0 | 2 | 15 | 11 | 12 |
| X | 14 | 6 | 20 | 19 | 0 | 0 | 19 | 16 | 15 |
| XI | 12 | 6 | 18 | 16 | 0 | 0 | 16 | 20 | 18 |
| XII | 7 | 7 | 14 | 16 | 0 | 0 | 16 | 19 | 17 |
| XIII | 13 | 2 | 15 | 11 | 0 | 0 | 11 | 17 | 15 |
| XIV | 22 | 2 | 24 | 15 | 0 | 0 | 15 | 10 | 10 |
| XV | 24 | 1 | 25 | 22 | 0 | 0 | 22 | 17 | 16 |
| XVI | 11 | 4 | 15 | 13 | 0 | 0 | 13 | 23 | 21 |
| XVII | 12 | 5 | 17 | 12 | 0 | 0 | 12 | 15 | 14 |
| XVIII | 12 | 4 | 16 | 10 | 1 | 2 | 13 | 11 | 10 |
| XIX | 16 | 4 | 20 | 14 | 0 | 0 | 14 | 19 | 17 |
| XX | 17 | 1 | 18 | 13 | 1 | 0 | 14 | 20 | 18 |
| Average | 12.9 | 5.2 | 18.1 | 14.8 | 0.1 | 0.2 | 15.1 | 17.7 | 16.2 |

Note. "Injured stems" at reaping time. mean ones with bleached ears (white ears). "Young stems" mean ones without ears.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| V | 18 | 2 | 20 | 17 | 2 | 0 | 19 | 20 | 19 |
| VI | 18 | 1 | 19 | 17 | 2 | 0 | 19 | 20 | 20 |
| VII | 12 | 2 | 14 | 12 | 2 | 0 | 14 | 15 | 15 |
| VIII | 16 | 1 | 17 | 15 | 2 | 0 | 17 | 24 | 22 |
| IX | 17 | 1 | 18 | 15 | 3 | 0 | 18 | 18 | 17 |
| X | 11 | 1 | 12 | 11 | 2 | 0 | 13 | 18 | 19 |
| XI | 17 | 1 | 18 | 15 | 3 | 0 | 18 | 21 | 21 |
| XII | 13 | 2 | 15 | 12 | 3 | 0 | 15 | 18 | 20 |
| XIII | 14 | 2 | 16 | 12 | 4 | 0 | 16 | 20 | 20 |
| XIV | 14 | 1 | 15 | 13 | 3 | 0 | 16 | 15 | 15 |
| XV | 8 | 6 | 14 | 12 | 4 | 0 | 16 | 22 | 22 |
| XVI | 22 | 1 | 23 | 18 | 5 | 0 | 22 | 18 | 19 |
| XVII | 17 | 1 | 18 | 16 | 1 | 0 | 17 | 16 | 16 |
| XVIII | 13 | 1 | 14 | 14 | 0 | 0 | 14 | 22 | 23 |
| XIX | 16 | 1 | 17 | 14 | 1 | 0 | 15 | 15 | 16 |
| XX | 18 | 1 | 19 | 17 | 2 | 0 | 19 | 18 | 17 |
| Averag. | 15.9 | 1.5 | 17.4 | 15.2 | 2.2 | 0 | 17.4 | 18.8 | 18.7 |

Note "Number of white ears"..... one ear comes up from one stem, therefore the number is equal to that the injured stems. "Young stems" mean stems without ears.

This table shows that when the stems are injured before the shooting time, they do not recuperate with new stems; and that all such injured stems usually appear as "white ears" at the reaping time, except very rarely; and that the number of the stems does not increase towards the reaping time, but rather, decreases (namely, some of the stems do not develop).

c. *Shooting period.*

During the shooting period if the stems are injured the ears upon them scarcely develop and are bleached, (these are called white or bleached ears, or white or bleached heads) sometimes they partly grow up however and bear seeds, or paddy.

An observation was made to ascertain the above fact, in the manner stated in the previous section. The appended table summarizes the results :—



**Table XXVIII.** Amount of injury at shooting period, Taihoku, 1913.

| Series | Plants injured at shooting period. | | | | | | | Plants uninjured at shooting period. | |
|---|---|---|---|---|---|---|---|---|---|
| | Investigation at time when injured. | | | Investigation at reaping time. | | | | Investigation at shooting time. | Investigation at reaping time. |
| | Number of uninjured stems | Number of injured stems | Total number of stems | Number of uninjured stems | Number of injured stems | Number of young stems | Total number of stems | Number of uninjured stems | Number of uninjured stems |
| I | 17 | 1 | 18 | 17 | 1 | 0 | 18 | 13 | 13 |
| II | 13 | 2 | 15 | 13 | 2 | 0 | 15 | 14 | 14 |
| III | 18 | 2 | 20 | 18 | 2 | 0 | 20 | 18 | 18 |
| IV | 10 | 4 | 14 | 8 | 7 | 0 | 15 | 24 | 24 |
| V | 13 | 1 | 14 | 13 | 1 | 0 | 14 | 17 | 17 |
| VI | 16 | 1 | 17 | 18 | 1 | 0 | 19 | 20 | 20 |
| VII | 15 | 2 | 17 | 15 | 4 | 0 | 19 | 16 | 16 |
| VIII | 10 | 6 | 16 | 8 | 8 | 0 | 16 | 21 | 21 |
| IX | 12 | 2 | 14 | 14 | 2 | 0 | 16 | 19 | 19 |
| X | 13 | 4 | 17 | 12 | 5 | 0 | 17 | 12 | 12 |
| XI | 14 | 1 | 15 | 13 | 3 | 3 | 19 | 18 | 18 |
| XII | 17 | 8 | 25 | 17 | 8 | 0 | 25 | 16 | 16 |
| XIII | 17 | 1 | 18 | 17 | 1 | 0 | 18 | 16 | 16 |
| XIV | 14 | 1 | 15 | 14 | 1 | 0 | 15 | 24 | 24 |
| XV | 12 | 2 | 14 | 12 | 2 | 0 | 16 | 18 | 18 |
| XVI | 10 | 4 | 10 | 14 | 4 | 0 | 14 | 20 | 20 |
| XVII | 13 | 4 | 17 | 13 | 4 | 0 | 17 | 19 | 19 |
| XVIII | 11 | 2 | 13 | 11 | 2 | 0 | 13 | 20 | 20 |
| XIX | 31 | 1 | 14 | 15 | 1 | 0 | 16 | 14 | 14 |
| XX | 18 | 1 | 19 | 17 | 2 | | 19 | 17 | 17 |
| Averag. | 13.8 | 2.5 | 16.3 | 13.8 | 3.5 | 0.2 | 17 | 17.8 | 17.8 |

Table XXVIII shows that during the shooting time if the plants are attacked by "Itten-O-Meiga", the uninjured stems are equal in number to those at the reaping time; namely, there is the same number of ears there were uninjured stems at the shooting period.

In short, the amount of the injury before the shooting time is greatest and it diminishes gradually both before and after this period. This does not certainly show the whole damage as it only covers the visible injury.

Two observations were made to ascertain how the injury of each time had effect on the crops.

In one observation forty paddy stools were cultivated in a special field, covered with four large breeding cages, having ten stools in each breeding cage. Later, many newly hatched larvae were set respectively, in the cage of the first series — before the ears grow in the rolled-up leaves, in the cage of the second series — before the shooting time, and in the cage of the third series — at the shooting time. In the cage of the fourth series the plants were kept free from larvae. After this the larvae living in the stems were killed, by cutting the injured stems, respectively, in the first series — before the shooting time, and in the second — at the shooting time, but in the third series the larvae were kept as they until the reaping time. On the same day the plants growing in each series were separately reaped, and the weights of the crops were compared. The appended table summarizes the results :—

**Table XXIX.** Percentage of rice crops diminished, Taihoku, 1908.

| Series. | Period when injured. | Number of uninjured stems. | Number of injured stems. | Percentage of injured stems. | Weight of crops (unhulled rice). | Percentage of crops (unhulled rice) diminished, compared with those of uninjured plants. | Percentage of crops (unhulled rice) diminished, compared with percentage of injured. |
|---|---|---|---|---|---|---|---|
| | | | | % | gr. | % | % |
| I | Before the ears grow in the rolled-up leaves. | 115 | 58 | 33.5 | 146.93 | 21.02 | 62.75 |
| II | Before shooting period. | 140 | 32 | 18.7 | 150.86 | 18.91 | 101.10 |
| III | During shooting period. | 129 | 37 | 22.3 | 145.09 | 22.01 | 98.69 |
| IV | Plants uninjured. | 169 | 0 | 0 | 186.04 | 0 | 0 |



The above table shows that if the plants are injured only at one period, the amount of the injury is greatest before the shooting time, and is least before the ears grow in the rolled-up leaves. These rates coincide with the rate of damage which appears externally. It also shows that if the plants are injured before the shooting time the percentage of the diminution of the crops is greater than percentage of the stems injured, this must however be very doubtful as the comparison was made with other uninjured plants, although the plants used in comparing were cultivated by exactly the same methods.

In the other observation eighty paddy plants (stools) were cultivated in a special field, covered with four large breeding cages, each having twelve plants in a cage. Later, many newly hatched larvae were set in each cage, as in the above observation, according to each period, and they were kept as they were, until the reaping time. The results were as summarized on the following table :—

**Table XXX.** Percentage of crops diminished, Taichiu, 1912.

| Series. | Period when larvae were set upon the plants. | Number of uninjured stems. | Number of injured stems. | Percentage of stems which injured. | Weight of crops (unhulled rice). | Percentage of crops (unhulled rice) diminished compared with uninjured plants. | Percentage of crops (unhulled rice) diminished compared with percentage of stems injured. |
|---|---|---|---|---|---|---|---|
| | | | | % | gr. | % | % |
| I | Before the ears grow in the rolled up leaves. | 257 | 104 | 28.8 | 181 | 40.5 | 140.6 |
| II | Before shooting period. | 318 | 29 | 8.3 | 259 | 14.8 | 178.3 |
| III | During shooting period. | 276 | 50 | 15.3 | 259 | 14.8 | 96.7 |
| IV | Plants uninjured. | 356 | 0 | 0 | 304 | 0 | 0 |

This table shows that if the plants are injured from each period- (i) before the ears grow in the rolled-up leaves, (ii) before the shooting time, and (iii) during the shooting time — until the reaping time, the amounts of the injuries diminish correspondingly in the order (ii), (i) and (iii); and that on both (i) and (ii) the percentage of diminution of crop is always more than the percentage of the stems

injured at those times.

In conclusion, if the amount of the injury is considered separately at each time, it is greatest at the period before the shooting time, and is least at the reaping time; if it is considered through the whole time, it seems as if it diminishes gradually from the young period as the reaping time is approached.

### G. Amount of Damage done by a Single Larva.

Owing to the degree of growth and the kinds of paddy, atmospheric conditions, etc., the amount of the damage done by a single larva, in general, cannot be stated; we may, however, consider it in two cases — (1) young time, when the stems are not grown up fully, and (2) after the stem is grown.

During three years (1911-1913) in the paddy fields, in each province of Formosa the withered tips of the stems (at the time when the plant was young), and the stems bearing the white ears (at the time when the plant was old), were out off at the roots, and the larvae living in the stems were counted, with the result shown below :—

**Table XXXI.** Number of larvae which were found in one hundred injured stems, Formosa.

| Locality. | Young stage of paddy. Number of larvae found in 100 stems bearing withered tip. | | | | Old stage of paddy. Number of larvae found in 100 stems bearing white ears. | | | |
|---|---|---|---|---|---|---|---|---|
| | Second crop, 1911 | First crop, 1912 | Second crop, 1912 | First crop, 1913 | Second crop, 1911 | First crop, 1912 | Second crop, 1912 | First crop, 1913 |
| Taihoku | 35 | 45 | 31 | 41 | 48 | 59 | 31 | 49 |
| Giran | 42 | 43 | 35 | 49 | 52 | 32 | 69 | 39 |
| Shinchiku | 36 | 47 | 41 | 42 | 47 | 39 | 27 | 38 |
| Taichiu | 29 | 41 | 32 | 38 | 59 | 31 | 26 | 42 |
| Nanto | 31 | 39 | 27 | 29 | 63 | 71 | 32 | 51 |
| Kagi | 27 | 37 | 21 | 21 | 43 | 42 | 21 | 33 |
| Tainan | 39 | 40 | 21 | 37 | 51 | 37 | 33 | 28 |
| Ako | 23 | 39 | 34 | 29 | 42 | 23 | 31 | 51 |
| Taito | 28 | 38 | 41 | 36 | 57 | 42 | 61 | 22 |
| Average | 32 | 41 | 33 | 36 | 51 | 41 | 37 | 40 |

In these two cases, the larvae, both dead and alive, were counted.



According to the observations, in the young stage of the paddy plants thirty-six larvae, on an average, were found in a hundred injured young stems; this probably means that a single larva could injure 2.8 young stems. At the time when the plants are old forty-three larvae were found in a hundred white-ear-bearing stems; this probably permits the inference that a single larva can injure 2.3 full-grown stems. This inference is rendered possible because although many of the larvae are by natural enemies, the dead body of the larva, or a part of it, is left in the stems.

In the laboratory, five larvae were reared singly in five breeding cages in both the young and old stages of the paddy plants. In these two observations a single larva attacked on an average 3.2 stems when the plants were old, and 4.5 when the plants were in the young stage.

In short, a single larva of "Itten-O-Meiga" injures at least two or three stems of rice plant.

### H. Parasites and Predaceous Enemies.

#### i. Parasitic Insects.

The habits of the larvae in feeding on paddy are such that they are well-protected from parasites after the first one or two days of their life, or after the removing time, during which time they have been boring down through the stem or rolled-up leaves into the centre of the stem. When once well inside the stem it is practically impossible, with a few exceptions, for parasites to reach the larva, unless it should leave the stem, which is often the case. But in such a case, the absence from the stem is very short. These conditions explain the small percentage of parasites shown in section 2. Several parasites have been bred larvae collected in the field.

**A. Seaka-Komayubachi.** (Pl. XII, figs. 1—8).

*Shirakia dorsalis* Matsumura (*Bracon*), schaedl. u. Nuetzl. Ins. von. Zuckerrohr Formasa, pp.49 & 84, pl. XXX, fig. 7 (female), 1910.

*Shirakia schoenobii*, Viereck. Proc. U. S. Nat. Mus., vol. 44, p. 643, 1913.

This species belongs to the Family *Braconidae*, of the Order *Hymenoptera*.

**(i). Description.**

**Female.** Body somewhat flat, broad, covered sparsely with fine white hairs. *Head* shining, reddish brown to yellowish red-brown; short, but vertically long, broad, somewhat pentagonal in front view; face square, finely sculptured and indefinitely punctured, with a blackish brown stain on each side; front with a large black mark occupying the middle half and extending from between the insertion of the antennae upward between and around the ocelli. Ocelli collectively circumscribed by a furrow that is prolonged below the exterior ocellus and ends in a poorly developed carina between the antennal fossae; lateral ocelli a little nearer to the anterior ocellus than to each other and nearly three times as far from the nearest eye margin as from each other; ocelli yellow, round. Occiput brownish, stramineous, finely sculptured, sprinkled with indefinite punctures. Cheeks and malar space stramineous, the former sculptured somewhat like the occiput, the later finely sculptured. Mandibles with blackish tips, palpi brownish, other mouth parts stramineous. Antennae 50-jointed, mostly blackish brown, the basal joint and first of the flagellum yellowish red-brown and very small; scape stramineous beneath, inverted bottle-shaped, largest; pedicel half as long as the scape; flagellum, excepting the first joint, filiform, bearing fine hairs.

*Thorax.* Pronotum very short, stramineous, its sides stramineous along the upper and lower edge, elsewhere blackish, its furrow foveolate; mesonotum large, reddish brown to yellowish red-brown, shining, hardly sculptured, the praescutum strongly convex anteriorly, the notauli almost meeting before reaching the hind edge of the mesonotum and continued close to the hind edge almost as one longitudinal furrow, the scutellum a little smaller than the praescutum and a rightangled



triangle, with a transverse brownish black carina near the base. Tegulae pale yellowish brown, small, nearly broadly crescent-shaped in lateral view. Metanotum mostly black, bearing sparsely somewhat long, fine hairs, the praescutum small, yellowish brown. Mesonotum greyish black, between the fore coxae yellowish brown; mesopleurae blackish brown and sculptured above the middle, blackish red and almost sculptureless below the middle; metasternum and metapleurae black, the latter sculptured somewhat like the upper half of the mesopleurae.

*Wings* pale brown; stigma and veins blackish brown; both the fore and hind wings reaching further than the end of the abdomen.

*Legs* moderately large; fore coxae internally, distal trochanters of fore legs, fore femora posteriorly and also above the longest axis in front brownish stramineous, otherwise the fore legs are mostly blackish; mid and hind femora reddish brown, the remaining parts of the mid and hind legs black, except for a rather stramineous annulus near the base of the tibiae; claws with a stout tooth at base; empodia surpassing the tips of the clows; hind onychii as long as the two preceding joints combined.

*Abdomen* rather stout, somewhat flat, dorsal surface more or less rugose and bearing fine hairs, six segments visible; first dorsal segment rugose except on the vertical anterior face, which is smooth, black, apparently twice or more than twice as wide at the apex as the median lateral length, the dorsal face convex and flanked by depressed broad lateral margins, with a small triangular yellowish spot in the middle near the posterior margin, the lateral lunulae one on each side; second dorsal segment broad posteriorly, the face mostly blackish brown and rugose, with its furrows stramineous, as is the posterior edge between the furrows; the area defined by the furrows blackish, lunulae stramineous, the apex of this segment arcuate and more twice but less than three times as wide at apex as the segment is long down the middle; fale suture stramineous, with rugulose band down

the middle, this band broadest at base and becoming attenuate apically; third to fifth dorsal segments with lateral margins brownish stramineous; the apical edge of the third and fourth, and apical third of the fifth segments brownish stramineous to pale stramineous, elsewhere the third to fifth segments inclusive, are blackish; sixth dorsal segment concealing the seventh, convex, almost semi-circular in outline, mostly rather dark stramineous; pygidium in outline and colour nearly like the sixth dorsal segment; hypopygidium acute, its tip falling far short of the apex of the abdomen; exserted portion of the ovipositor apparently half as long as the abdomen, black, at base and internally reddish brown.

Length 4.5—5 mm.

**Male.** Compared with the female this differs chiefly as follows:— Abdomen slender, yellowish brown, except the head and thorax, which are pale reddish brown. Antennae 53-jointed, pale brown. Legs stramineous, excepting the tibiae and tarsi, which are rather brownish to dark brown. Oblique lines of the face of the second dorsal abdominal segment almost entirely concealing the tip of the abdomen; otherwise essentially as in the female except that the parts not mentioned as differing in colour are uniformly, or nearly uniformly stramineous. Length 5 mm.

**Larva.**

Milky white; bent dorsally; 13-segmented; somewhat cylindrical, narrowed towards each end; sixth to tenth segments largest, strongly convex dorsally, with an elevation on each lateral segment; first segment with two following segments not convex dorsally, small, with a transverse furrow on the dorsal surface, more or less raised on the lateral surfaces; fourth and fifth segments with somewhat clear elevation on the dorsal surface, elevation of the lateral surface distinct like those of the following segments; eleventh segment without distinct elevation of the dorsal surface; twelfth segment very small, without elevation on dorsal or lateral surfaces; ventral surfaces of



each segment almost flat, with a narrow transverse elevation near the posterior margin of each segment, each lateral margin with two longitudinal furrows, which are distinct on the second to the fifth segment, and the remainings indistinct, but the inner ones somewhat distinct. Head very small, placed obliquely nearly round in front view, very short, darker than the body; mouth parts brown at all the sutures. Anal segment small, opening of the anus near the dorsal margin at the end, with a projection in the middle at the end of the ventral surface, the front of the anus somewhat flattened narrowly and without any fine transverse folds. Length of full-fed larva 8.5 mm.

**Pupa.**

At first yellow, becoming gradually pale reddish brown; later the eyes change to black, after that the antennae become brown, next the ovipositor, and lastly the thorax and abdomen change to brown. Body flat; head deflexed upon the prosternum; mandibles closed and the palpi extended straight downwards until their apices nearly touch. Antennae commence at the front of the ocelli, passing along the inner sides of the eyes and bending obliquely downwards; strongly bent downwards at the third joint, and the antennae touching in the middle of the ventral surface, passing along the outer edge of the mouth parts, and extending to the end of the abdomen. Legs are pressed closely to the sides of the body; in the fore legs the femora are drawn forward, reaching to the eyes, the tibiae are folded back upon the femora and the greater part can be seen from the back, the tarsi lie obliquely with the ends reaching to the outer side of the antennae; mid legs cannot be seen from the back, the femara and the tibia are folded under the wing and lie along the side of the thorax, the tarsi lie along the outer side of the antennae in a continuous line; in the hind legs the femora extend to one third of the lateral edge of the metanotum, the tibia reaches to the second abdominal ventral segment and the tarsi extend to near the middle of the

abdominal ventral surface. Ovipositor bent upon the dorsal surface of the abdomen and extending to the margin of the fifth segment. Length 4.5—5.3 mm.

**Cocoon.**

Generally white, the upper end somewhat truncate, broadened towards the lower end, both ends more or less yellowish gray. Very thin, the inner surface in colour almost the same as the outer one and somewhat shining. The outer surface covered with a very loosely spun layer which is thickened at the part which adheres to the inside of the paddy stem. At the base of the inside of such a cocoon a brown liquid and the old skin are generally found remaining, the former changes to a dark colour towards the time of emergence of imago. Length 7.5—8.5 mm.; width 2.3 or more mm.

**(ii) Life history.**

This Hymenopteron has probably five or six generations in a year. Some of the specimens were bred out in the laboratory, and the life cycle was found to occupy about three weeks on an average, some ten days of this spent in the pupal stage. From one of the larvae an adult parasite was reared, and at one time I obtained two specimens of *Shirakia* from one larva of "Itten-O-Meiga".

The parasitic adults usually come out of the cocoon between seven and nine o'clock in the evening, and they rest on the cocoon for about thirty to fourty minutes. During this time the wings are stretched fully and shaken four or five times. After these motions they try a short fiight and leave the cocoon. After ten to twenty-four hours the females are fertilized. The female deposits her eggs in the larvae which are in stage IV, very rarely in those in stage III or V. In the laboratory it has been observed only once that the female stung through the rice-stem, but it is still unknown how it deposits the eggs upon or within the skin of the larva of "Itten-O-Meiga" and how many eggs are deposited. Very often it is observed that the female stings through the skin of the larva which is removing



from one stem to another. In this case the eggs are deposited within the larval body, but the number of eggs laid in a larva is quite unknown, in other cases. It has been observed that one parasitic grub feeds in a larva, or very rarely, two grubs in one larva.

The eggs are very small, elliptical in shape, and milky white in colour, gradually assuming a darker tint; they are about half a milimetre in length.

After it has been stung by the Braconid, the larva continues to feed, but probably at a much diminished rate, for two or three days. It now becomes very sluggish and eats the inside of the stem of paddy in a desultory manner, chewing it into small bits, like sawdust, but larger than those it consumes under normal conditions, and many of them it fails to swallow. These chewed particles usually remain in the rice-stem, webbed together loosely by a few delicate strands of silk spun by the larva. By the time the parasitic grub is full-fed, the larva has ceased feeding entirely and is scarcely larger than when it was first attacked. Sometimes such a parasitised larva moults, and very rarely it spins a very loose cocoon. The parasitic grub always lives between the alimental canal and the skin, and when full fed it bores its way out through the skin of the quiescent larva, leaving a rather small black scar to mark the point of its emergence, which is generally on one side of the body, near the first segment. Once free from the larva, parasitic grub always bores a large and irregular hole (from which the Hymenopteron emerges) through the rice-stem wall, nearly along the whole length of the stem. Soon after, it spins its pupal cocoon on the inside of the stem, near the hole Very rarely it pupates in the cocoon of "Itten-O-Meiga"; in this case the cocoon is generally strengthened by the grub. After the parasite has left it the larva usually lives for one or two days, but does not feed probably at all during that time. Before death it gradually shrinks and dries up. Larvae of "Itten-O-Meiga" which are parasitised almost always acquire a pale grey colour and a shriv-

elled appearance which is quite characteristic, even before any other external sign of the parasite is evident.

This Braconid has been bred out very often from *Chilo simplex*, and *Nonagria inferens*. The breeding of the Braconid is not difficult, in fact, it is rather easier than that of hymenopterous egg-parasites usually, when *Nonagria inferens* is used for its host.

Up to the present time the *Shirakia* is not known to be attacked by any species of secondary enemies(parasites), however, these may be present in rare instances.

b. **Zuimushi-Haraguro-Yadoribachi.** (Pl. XII, figs. 9—16).

**Amyosoma chilonis,** Viereck. Proc. U. S. Nat. Mus., vol. 44, p. 640, 1915.

This species belongs to the Family of *Braconidae*(*Hymenoptera*).

(i). **Description.**

**Female.**

Very small, polished. *Head* slightly broader than the thorax; transverse, convex towards the back; reddish brown except the vertex and the occiput, above a horizontal line drawn at a tangent to the upper edge of the occipital foramen. Ocelli are placed on a back, somewhat round elevation, which is surrounded with a fine furrow; lateral ocelli apparently a little nearer to the anterior ocellus than to each other and approximately twice as far from the nearest eye margin as from each other. Eyes moderate, situated on the sides of the face, black, somewhat convex. Antennae black, a little shorter than the length of the body; 35-jointed; basal joint small, brown; scape largest; pedicel nearly as long as the basal joint, but a little thicker; flagellum filiform, the surface rugose, all the joints narrowed toward the tip, the terminal joint conical.

*Thorax* almost oval, strongly convex towards the back, yellowish red; metapleurae black; tegulae yellowish brown. *Wings* pale yellowish brown, at the base yellow, large, the veins and stigma blackish brown. *Legs* moderately developed; fore legs with their coxae and trochan-



ters, tip of femora, tibiae and tarsi more or less stramineous or brownish stramineous, the remaining parts blackish brown; mid and hind legs mostly black or very rarely blackish, with the end of every joint slightly yellowish brown.

*Abdomen* short and broad, black except for the membranous portion of the first and second segments, and apical margin of the third and following dorsal segments; the apical margin interrupted medially in third, fourth and fifth segments, broadest laterally, all are yellowish white; first and second segments narrow, the membranous portions, namely, the lateral sides flat and placed perpendicularly, very often these two segments yellowish white entirely; third segment broadest; the remaining parts of the abdomen somewhat triangular in the dorsal view. Ovipositor in the exserted portion black, large, apparently as long as the first and second abdominal segments united. Length 3.3—3.6 mm.

**Male.**

Essentially as in the female, but differs chiefly as follows:— Body in general smaller than the female. Head black, with pale reddish brown mouth parts; antennae 33-jointed; ocelli large, the lateral ocelli on the occiput and the anterior ocellus on the vertex, placed far apart; fore legs and mid trochanters, and the base of the mid tarsi stramineous, the propodaeum partly reddish; abdomen polished more than the female and lighter in colour. Length 3.3—3.5 mm.

**Larva.**

Soft, milky white, 13-segmented, more or less flattened, the back strongly convex, the ventral surface flat, slightly bent backwards; the secoud to eleventh lateral segments with a longitudinal elevation on each one. Each of the dorsal segments divided by a transverse furrow, except the first, twelfth and thirteenth segments, the front portion crescent-shaped; on the transverse furrow of the first to fifth segments a row of small protuberances. Head small, darker than the body, with a Y-shaped line on the dorsal surface. Mouth

parts pale brownish yellow; labrum broad, transverse; labium somewhat triangular. The terminal segment a little larger than the head, and with transverse folds at the end into which the anus opens; the lower surface of the anus smooth and shining. Length when full grown, 8 mm.

**Pupa.**

At first yellowish white; before the emergence nearly the same colour as the adult. Body short and flat; the lateral margins of the abdomen slightly bent downwards; ovipositor placed on the back of the abdomen, extending to the posterior margin of the fourth abdominal segment. Length 3—3.5 mm.

**Cocoon.**

Big and somewhat cylindrical, grayish white; the upper end yellowish, somewhat truncate, covered with a special thick membrane; the lower end varies in shape, being connected with the inside of the stem by a few strands of silk. The outer layer is loose and very thin, with several particles of dust adhering to it. The inner surface of the inner layer dark, polished.

**(ii). Life history.**

A number of specimens were bred out in the laboratory with several paddy and sugar cane *Pyralids* in breeding jars, and from each one of these an adult parasite was reared. The life cycle is about twenty days, but the number of generations in a year is still unknown. At no time have we obtained more than a single grub of *Amyosoma* from one larva of "Itten-O-Meiga".

The emergence of the adult always occurs during day-time, the *Braconid* is rather active, and it deposits the eggs in a very short time. Generally the female stings through the stem wall of paddy by means of her rather stout ovipositor, and deposits the eggs probably in the larvae of "Itten-O-Meiga" etc. Only once in my observations was it known that it stung through the skin of the larva removing without a temporary house. After the larvae have been



stung by the *Amyosoma* their life cycle continues like those which have been attacked by the *Shirakia*. The habits of the parasitic grubs feeding in the larva are the same as those of the preceding species. When the parasitic grub is full-fed it leaves the larva, boring generally through the skin of one side of the body, near the second pair of prolegs. Afterwards it begins the spinning of the cocoon, in the surrounding space, which is of course the inside of the stem. Before the spinning it does not make the emergence hole, which is always bored by the larva. Generally the larva of "Itten-O-Meiga" is in stage V when the grub of the *Amyosoma* leaves it. The pupal cocoons of this Hymenopteron are hardly ever found in the subterranean stem. The breeding of this species is probably much easier than that of the preceding species.

**c. Madara-Komayubachi.** (Pl. XI, fig. 1).

**Stenobracon maculata** Matsumura, Schaedl. u. Nuetzl. Ins. Zuckerrohr Formosa, 1910, p. 50, pl. XXX, fig. 8.

This handsome species belongs to the Family of *Braconidae* (*Hymenoptera*)

**(i). Description.**

**Female.**

Larger than the preceding two species; slender, shining, bearing sparsely pale coloured hairs. *Head* large, broader than the thorax, black, except for the ventral half and the mouth parts which are yellowish red. Antennae slender, longer than the length of the body, mostly brown, but on the basal half mostly yellowish brown, 79-jointed; the first joint small, yellow; the second joint (scape) black, largest; the third (pedicel) short and thick; the flagellum filiform, the first joint longest and blackish brown with yellowish brown base, the second shorter than the first and cylindrical, pale blackish brown, the remaining joints nearly equal in length except for the terminal joint which is small. Ocelli placed on the

triangular elevation in the vertex, nearly touching each other, the distance between each nearly equal, pale yellow. The face in the middle with a fine longitudinal sulcus from the lower edge of the triangular elevation to the clypeus. Eyes somewhat oval, slightly convex, black.

*Thorax* narrow, one third as long as the abdomen, yellowish red. Pronotum small, much narrower than the head and shorter, the posterior margin broadly margined and curved forwards. Mesonotum longest and broadest; praescutum narrow, reaching to the scutellum, and dividing the scutum; scutum placed separately on the sides, the inner margin nearly straight, the outer margin slightly curved outwards; scutellum somewhat semi-circular, moderately large. Tegulae paler than the notum. Metanotum large; the postscutum very short, like a transverse elevation; the scutellum large, narrowed toward the end. *Wings* narrow and long, pale yellow, subhyaline; the outer margin and the caudal half of the inner margin broadly fumated, the stigma yellow; fore wings with two large black spots, the outer one of which is smaller than the inner one, placed between the costal margin and the middle of the wing, the inner spot between the costa and the inner margin of the wing; veins yellowish red.

*Legs* slender, of the same colour as the thorax, the terminal tarsal joint, claws and empodium dark.

*Abdomen* slender and flat, compressed from the fourth segment toward the end, honey yellow, except for the fifth (and sometimes the sixth) segment black and shining; the first segment slender, slightly oblique towards the back, with a longitudinal sulcus on the lateral margin; the sulci closed at the base and extended to the outer edge of the process of the anterior margin of the second dorsal segment; the second segment broadest on the sides, with a sulcus which is between the outer edge of the process and the lateral end of the posterior margin, which is curved posteriorly and concave in the middle; the third segment with a transverse furrow near the anterior margin, in



the centre a fine furrow, triangular in form; the sixth small somewhat cylindrical; the seventh smaller than the sixth, about the same in shape as the preceding one. Ovipositor slender, longer than the body, reddish orange yellow, the lateral gonapophyses browish black. The ventral surface of the body pale yellow.

Length 7.5 mm.

**Male.**

Compared with the female this differs chiefly as follows:— Antennae with more than 85 joints; the sixth abdominal segment black, the remaining abdominal segments yellowish red, the seventh dorsal abdominal segment somewhat semi-circular and not compressed, the eighth segment very small, with cerci at the end. Length 9 mm.

**Larva.** Like Zuimushi-Yadoribachi, but almost pale brown when it is full-fed.

**Cocoon.** Large; 12 mm. in length and 2.5 mm. in width. Outer layer very loosely spun, pale yellowish brown; inner layer thin but closely spun, the inner surface shining and paler than the outer layer. At the end of the inside some brown liquid is reserved, which at last dries up and changes to purplish black solid matter.

**(ii). Life history.**

This is entirely unknown. Only five specimens were reared from the larvae of "Itten-O-Meiga" in the laboratory. These larvae were collected in the field of Taichu-Cho and Ako-Cho districts, although the species was very often collected in the field and mountainous districts of Formosa. According to Prof. S. Matsumura and Mr. M. Ishida it is known that the *Stenobracon* attacks the sugar cane borers. Probably its chief host is not "Itten-O-Meiga".

**d. Zuimushi-Yadoribachi.** (Pl. XIII, figs. 1—17).

**Apanteles simplicis** Viereck. Proc. U. S. Nat. Mus., vol. 44, p. 645, 1913.

This belongs to the Family *Ichneumonidae* (*Hymenoptera*).

**(i). Description.**

**Female.**

Slender, pale brownish yellow. *Head* broader than the thorax, short. Antennae dark yellowish brown, slender, shorter than the body, bearing fine hairs, 36-jointed; the basal joint and pedical very small; scape largest; flagellum filiform, all the joint cylindrical, almost equal in length and width. Antennal fossae further from each other than from the eye margin, occupying in a round flattened pale reddish brown space. Eyes black, oval, extremely wide apart, the inner margin nearly straight. Ocelli placed in a black triangular slightly elevated area on the vertex, yellowish red, polished; lateral ocelli nearer to the anterior ocellus than to each other. Mouth parts same in colour as the body, with pale brown labrum; palpi same in colour as the body.

*Thorax* narrow, about one third as long as the abdomen, the dorsal surface yellowish red brown, the ventral surface pale yellow, bearing sparsely fine hairs, and scarcely punctate. Pronotum very small, almost invisible in dorsal view. Mesonotum largest; praescutum longest, extending to the anterior margin of the scutellum; scutum brown, divided into lateral pieces, which are narrower than the praescutum, about half as long as the praescutum; scutellum small, somewhat lozenge-shaped, convex, yellowish white or pale yellow, with two fine longitudinal carinae; tegulae very small, somewhat triangular, paler. Metanotum a little narrower than the mesonotum and nearly equal to it in length; praescutum short, the anterior margin slightly elevated and blackish brown or pale yellowish brown and strongly curved inwards, the mid part nearly flat, the posterior margin distinctly margined; scutellum large and long, narrowed towards the end, the posterior margin strongly curved forwards and bearing a pale brown small spine on each end, the face punctate and with four longitudinal carinae.

*Wings* short and rather small, hyaline, iridescent, the stigma dark, veins slightly dark.



*Legs* slender, paler than the body, bearing fine hairs; hind legs largest, the end of the tibia, tarsi and empodium dark, bearing two spines at the lower edge of the tibia; the fore and mid legs concolorous except for the empodium, which is more or less dark at the base.

*Abdomen* extremely slender, compressed; first segment club-shaped, nearly as long as the tibia of the hind leg, black at the base; second segment a little longer than the first, distinctly wider at the apex than at the base, which is black, the surface reticulate; third segment to sixth segment extremely compressed, narrowed towards the pygidium; the third segment black at the base, slightly longer than half the length of the second segment, the fifth and sixth as long as the third, the fifth a little longer than the third; the seventh very small, with a longitudinal sulcus in the middle. Ovipositor at exserted portion almost black, 9 mm. in length, pointed.

Length 8 mm.

**Male.**

This differs from the female chiefly as follows:—

Head and meso-scutellum yellowish white. Ocelli blackish brown, large, the space where the ocelli are placed not black nor triangularly elevated; meta-scutum and meta-scutellum blackish brown at base. Abdomen about twice as long as the thorax, the first segment not distinctly clubbed, the third, fourth and fifth dorsal segments nearly equal in length, the sixth a little longer than the preceding one, the seventh extremely narrowed toward the apex, the eighth very small and almost entirely concealing the tip of the abdomen; cerci long.

Length 7 mm.

**Larva.**

Cylindrical, narrowed toward the ends, pale yellow. Head small and short, roundish in the front view, the dorsal surface somewhat flat. Antennae very fine, bristle-like, colourless; eyes colourless, round and flat, rather concave, placed near the outer margin of the

base of the antennae. Mouth parts small, mandibles fine and black. The dorsal surface of the body with two indistinct transverse folds on each segment ; the fifth to ninth segment with a large transverse elevation on the anterior margin and each elevation divided into two parts by a longitudinal sulcus, but those on the fourth and fifth indistinct ; the tenth segment with an indistinct transverse elevation on the anterior margin. The ventral surface with a large, transverse fold near the joint of each segment. Anal segment small, round in the hind view. Length when full-grown about 12 mm.

**Pupa.**

When newly emerged pale milky white. Just before the emergence of the imago yellow, except for the lateral surface of the abdomen, almost colourless. Antennae not extended farther than the tip of the abdomen, reaching to the third joint of the hind tarsi. Length 9 - 9.5 mm.

**Cocoon.**

Cylindrical ; both ends rounded regularly, very rarely narrowed suddenly at the lower end. It is formed with two layers like that of the other species ; the outer layer very loose, white; the inner layer thick, dark brown, the inner surface shining and with a white transverse band about 1 mm. in width, at about one third of its length; this band is visible through the transparent outer layer. The lower end very often with irregularly spun sheath which is an extension of the outer layer. In the inside there is some liquid and the old skin, as in the other species. Length 7 mm., width 1.7 mm.

**(ii). Life history.**

This *Ichneumon* can be reared from the larvae of *Schoenobius incertellus*, and *Chilo simplex*, and it occurs usually in the middle and southern parts of Formosa, very rarely in the northern part. At no time have we obtained more than a single specimen of this species from one larva of rice Pyralids. The complete life cycle has not been studied. The adult generally emerges about eight to nine



o'clock in the morning ; immediately after its emergence it stretches the wings by means of the regular movements of the hind legs ; it next clears the ovipositor and at last the head. The movements take place almost in the order mentioned above, but they are sometimes alternated. About twenty to thirty minutes after emergence of imago the body strengthens and the colour becomes darker. The parasitic grub feeds in the larvae which are in stages II to IV, and eats the whole contents of the inside of the larva. When full grown it crawls out of the skin, and spins the pupal cocoon in the inside of the paddy stem, or very rarely between the sheath and the stem. The cocoon generally hangs instably, and it is not found to be placed in the subterranean stem. Sometimes it is observed that the dead larva of "Itten-O-Meiga" remains in the cocoon.

e. **Zuimushi-Yokojima-Yadoribachi.** (Pl. XIV, fig. 1—6).

**Eripternimorpha schoenobii** Viereck. Proc. U. S. Nat. Mus., vol. 44, p. 646, 1913.

This species is the largest parasite of "Itten-O-Meiga", and belongs to the Family *Ichneumonidae* (*Hymenoptera*).

**(i). Description.**

**Female.**

Black, sericeous and finely sculptured. *Head* slightly wider than the thorax, short, the posterior margin strongly concave ; the front somewhat concave in the middle, with a depression in which the antennae are inserted, with a carina reaching from between the antennal fossae almost to the anterior ocellus, anterior edge of the clypeus slightly submarginate ; mandibles blackish, reddish brown at the base, the basal half reticulate ; palpi dark brown. Antennae slender, but shorter than the body, 31-jointed ; the basal joint yellowish brown, sometimes black ; scape black, pedicel and flagellum blackish brown. Eyes black, placed on the sides of the front half of the head, elliptical, more or less convex. Ocelli small, rouud, lateral ocelli nearer to the anterior ocellus than to each other and

half as far from the eye margin as they are distant from each other.

*Thorax* slender, black, except for meta-scutellum, yellowish red; mesoscutum on the lateral margins with a fine longitudinal carina, which reaches to the meso-scutellum; meta-scutellum with propodeum large, with a fine transverse carina before the middle, the carina divided into two in the middle and its lateral ends obtusely bent forwards, and with a fine, W-shaped median carina posteriorly, the posterior margin curved forwards and the lateral angles slightly pointed, sometimes with (each) two pale black spots near the anterior and posterior margins; tegulae small, rectangular; posterior margin of the mesopleurae reddish; metapleurae black.

*Wings* pale brown, veins and stigma dark brown. Legs slender, well-developed, with two spines at the lower end of the tibiae; fore coxae, each trochanter and the base of each femur black; each tarsus and the remainder of the base of the mid and hind tibiae dark brown, the remaining parts yellowish red; the claws dark brown and with a small spine at one third along the lower edge.

*Abdomen* slender; the first segment with the petiole subcylindrical and with a poorly-developed longitudinal carina on each side above, but with a distinct carina between it and the ventral segment; reddish at base and ventrally, elsewhere black; post petiole reddish yellow, rather depressed, distinctly wider at apex than at base; the lateral longitudinal carina distinct, extending from the spiracles towards the apex; the dorsal carina extending from the basal half of it to the apex of the petiole; the second dorsal segment reddish along the apical edge, apparently two and a half times as wide at apex as the first is wide at apex, and distinctly wider at apex than at base, with pale oval thyridia that are nearer to the base than to the lateral edge, and with a polished embossed area between them and the base, the spiracles nearly three times as far from the base as from the lateral edge; the third dorsal segment reddish brown, blackish brown along the posterior margin, apparently more than twice as wide



at apex as the median lateral length; the eighth dorsal segment whitish and membranous at the apical half. Ovipositor large but short, the exserted portion as long as the first dorsal abdominal segment; the lateral gonapophysis black, the remainder dark reddish brown. Length 7—10 mm.

**Male.**

From the female it differs chiefly as follows:—

Body black except for the femora and tibiae of the fore legs, and the middle large part of the mid and hind femur, which are yellowish red; antennae 31-jointed, the flagellar joints beyond the middle concave beneath; mid coxae mostly reddish, mid onychia somewhat larger than the mid metatarsi; postpetiole narrower than that of the female, almost parallel-sided, slightly concave in the middle of the dorsal surface, the dorsal carinae reaching to the apical edge and slightly curved inwards in the middle, the lateral carinae swollen at the point of connection with those of the petiole; second dorsal abdominal segment apparently three times as wide at the apex as the first, the spiracles nearly five times as far from the base as from the lateral edge. In some specimens the apical half of the third dorsal segment and an apical margin of the fourth and fifth dorsal segments yellowish, the basal half of the third segment mostly blackish; the apical half of the seventh dorsal segment like the apical half of the eighth in the female. Length 7.5—10 mm.

**Larva.**

Essentially as in Ako-Zuimushi-Yadoribachi from which it differs chiefly as follows:— Larger and darker.

**Pupa.**

When newly emerged pale yellow; before the emergence of the imago dark like the adult. Antennae slender, reaching to the preceding segment of the pygidium, in the female extending to the end of the hind tarsi. Mouth parts long, triangular, reaching to the apical edge of the fore coxae. Thorax distinctly shorter than the

abdomen; wings extending to the spical edge of the mid coxae; hind legs in the male reaching to the fifth ventral abdominal segment and in the female extending to near the basal edge of the terminal ventral segment. Ovipositor placed on the back of the abdomen and reaching to the apical margin of the fifth dorsal abdominal segment. Length 7—7.5 mm.

**Cocoon.**

The outline is like the cocoon of the following species, but differs as follows:—

Large; both the outer and inner layers somewhat thick, the outer surface with somewhat reticulated carinae, grey in colour. Length 11.5 mm., width 2.27 mm.

**(ii). Life history.**

This species has been bred out in the laboratory with several larvae of *Pyralidae* and *Noctuidae*, and from each one of these an adult parasite was reared. The hosts are as follows:—

*Schoenobius incertellus* Wlk.; *Chilo simplex* Butl.; *Scirpophaga surifera* Zell.; *Diatraea striatalis* Snell.; *Nonagria inferens* Wlk.; *Laphygma exigua* Huebn.

The number of generations in a year is probably five or six. The adult emerges mostly in the afternoon, and after about two hours it is able to fly away from the paddy. It is very active, and the coupling time is very short. It has often been observed to sting through the stem, but it is still unknown whether it can sting directly through the skin of the larva. The parasitic grub is always found living in a larva in stage V. At no time have we found it feeding in a younger one. When the parasitic grub is full grown, it immediately comes out of the victim, boring through the skin at one side between the first and second prolegs. After this it spins a pupal cocoon in the subterranean stem of paddy to which the cocoon is attached at the dorsal end. Of course if it attacks the larvae of the sugar cane Pyralids it always spins the cocoon betweeen



the leaf and stem. After the pupa has matured the delicate imago emerges, boring through the cocoon at one side of the upper end, and comes out of the stem, crawling through the hole made by the parasitised larva. The length of the pupal stage as almost always from seven to ten days. This parasitic Hymenopteron occurs all over the Island.

**e. Ako-Zuimushi-Yadoribachi.** (Pl. XIV, fig. 7—14).

**Eripternus? akoensis** n. sp.

This species belongs to the Family *Ichneumonidae* (Hymenoptera), and is allied to the preceding species. Two examples of this species were found in the larvae of "Itten-O-Meiga" at Ako (Formosa), 1912, and from one of these an imago was reared; the other being attacked by a secondary Hymenopterous parasite.

**(i). Description.**

**Female.**

Small, polished, black, sericeous and with fine sculptures.

*Head* short, wider than the thorax; the anterior margin somewhat straight; the posterior margin curved forwards and finely elevated, with an indistinct longitudinal sulcus on the dorsal surface; labrum slightly curved downwards at the apical edge and margined narrowly, reddish brown; mandibles stramineous, the apical end black and toothed; palpi stramineous. Antennae setaceous, big, brown, nearly as long as the body, 39-jointed, the basal joint, scape and pedicel pale yellowish brown; the first and last joints very small; scape largest and elliptical. Ocelli pale yellowish brown, round, large compared with the head; the lateral ocelli further from the anterior occllus than from each other, but the distance between the lateral ocelli, as far as to the eye margin. Eyes placed at the sides of the frons, oval.

*Thorax* large, essentially as in *Eripterniimorpha schoenobii*, Vier., but differing chiefly as follows:— The longitudinal carinae on the meso-scutellum indistinct; those on the meta-scutellum very distinct

and large.

*Wings* hyaline, somewhat fumated; the basal area and stigma pale yellowish white; the veins blackish brown.

*Legs* moderately large, pale yellowish red, except for the trochanter, which is pale yellow; the empodium blackish brown, and the apical end of the hind tibia and the tarsi brownish; the spines of the tibiae slender, paler.

*Abdomen* slender, compressed, yellowish brown, except for the first and the two apical segments which are black; the petiole somewhat quadri-carinate, the dorsal surface slightly concave at the base with a longitudinal carina at the lateral margins, the lateral surfaces somewhat concave and with a longitudinal carina at the lower margin, the ventral surface slightly covex; the post-petiole flattened, slightly curved backwards, distinctly wider than the apical edge of the petiole, the dorsal carinae continuous with those on the petiole, the apical edge somewhat reddish brown and marginate; the second segment slightly curved backwards, twice as long as the length of the basal edge, the apical edge a little less than double the basal margin, the lateral margins distinctly margined, the basal area dark; the second ventral segment strongly compressed, carinated sharply in the middle; the third dorsal segment square, slightly curved backwards, the basal margin more or less dark; the fifth and sixth dorsal segments shorter than the third, somewhat narrowed towards the apical end; the seventh dorsal segment small, the apical edge round, the ventral remaining segments strongly compressed. Ovipositor black, with the basal area reddish brown, apparently longer than the first dorsal abdominal segment in the exserted portion, and as thick as the antennae, somewhat curved.

Length 7—7.5 mm.

Male is still unknown.

**Larva.**

Milky white, mouth parts 0.1818 mm. in transverse diameter; the



mandibles black, the maxillae yellowish brown. The whole surface of the body bears close fine hairs. Each of the ventral segments (fifth to tenth and terminal) bears a low transverse elevation.

**Pupa.**

Milky white when newly emerged, the same in colour as the imago before the emergence, except for the apical portion of the abdomen which is paler than in the adult. Antennae reaching to the first joint of the hind tarsi. Length 7 mm.

**Cocoon.**

Pale greyish white; the outer layer very thin and loosely spun; the inner layer somewhat thick and closely spun. In the middle a liquid is kept in the lower third portion, which appears, as seen transparently from the outside to be greyish brown in colour.

Length 8 11.5 mm, width 2.27—1.66 mm.

**(ii). Life history.**

It is still unknown, the species having been reared only once from the larva of *Schoenobius incertellus*, at Ako(Formosa), in May, 1913.

The imago emerged at 7 to 10 o'clock in the morning, the cocoon being spun in the inside of the stem, and not underground; it was abherent to the paddy stem, and with a specially spun membrane at the upper one fourth of the cocoon. A dead larva in stage V was found in this cocoon. Probably this parasitic grub attacks the larva of "Itten-O-Meiga" in stage IV or V. There was a secondary parasitic Hymenopteron, but it was not reared successfully.

**g. Zuimushi-Kiashi-Yadoribachi.** (Pl. XV, fig. 1).

**Trathala? flavopedes.** n. sp.

This species belongs to the Family *Ichneumonidae* (Hymenoptera), and only two specimens have been reared from the larvae of "Itten-O-Meiga" at Taihoku.

**(i). Description.**

**Male.**

Black, somewhat shining, sericeous and finely sculptured. *Head* very short, transverse, wider than the thorax ; the frons slightly concave, without carina ; the occiput strongly convex. Ocelli placed on the vertex ; the lateral ocelli nearer to each other than to the eye margin, but nearer to the anterior ocellus than to each other. Eyes oval, placed at one half from front of the lateral margins, black. Antennae a little shorter than the body, 42-jointed, blackish brown, paler towards the tip. Mandibles yellowish brown, black at the end ; palpi pale yellowish brown. *Thorax* rather short, the carinae of meso-scutum reaching to the basal edge of the meso-scutellum, the tegulae small and pale yellow ; meta-scutellum with propodeum as long as the width and with ⊓-shaped carina. Wings moderately large, hyaline, the basal area pale yellow ; stigma yellowish brown, the veins brown. Legs slender, yellowish red, except for the trochanters and tarsi which are pale yellow ; the coxae and the apical portion of the hind tibiae black and the terminal joint of the tarsi and empodium pale blackish brown ; the tibiae at the lower edge with two yellowish white fine spines. *Abdomen* slender, compressed ; the petiole on the dorsal surface convex and on the lateral surface somewhat concave ; the dorsal and lateral carinae distinct, parallel-sided ; the post petiole broadened towards the basal one-third, the apical two-thirds nearly parallel sided, the dorsal surface slightly curved backwards ; the dorsal carinae of the petiole extend to one-third of the basal portion ; the second dorsal segment flat, two and a half times as long as the width of the basal margin, the apical margin yellowish brown, with two indistinct longitudinal carinae on the dorsal surface, the lateral edges somewhat distinctly margined ; the third dorsal segment apparently shorter than the second, flat ; the following dorsal segments compressed ; the eighth very small and somewhat triangular ; the ventral segments pale yellowish brown, in the middle strongly concave longitudinally, the fourth and the following segments concealed by the dorsal segments. Length 7.3 mm.



**Cocoon.** Essentially like that of Zuimushi-Yadoribachi.

(ii). **Life history.** This is not known. The adults emerge in July.

### h. Yadori-Nomibai, (Pl. XV, figs 2–4).

**Aphiochoeta parasitica.** n. sp.

This minute fly belongs to the Family *Phoridae*(*Diptera*).

**(i). Description.**

Adult minute, mostly pale brown. *Head* very short, transverse, a little broader than the thorax, blackish brown, seen from in front triangular, placed perpendicularly ; the frons almost flat, bearing comparatively long hairs near the eye margin, where are four or five setae in a row ; the area between the eye broad, rugose. Proboscis thick and long, greyish brown. Antennae thick and short, roundish, the basal portion stramineous and the apical half dark brown, 2-joint ; the second joint with a very long dark brown hairy seta near the outer margin. Eyes black to brownish black, placed at the lateral surfaces of the head, very far apart from each other. Ocelli placed close together on the vertex.

*Thorax* large, the anterior margin wider than the apical edge, the dorsal surface gibbose, greyish brown, bearing sparsely fine hairs ; the scutellum slender, slightly pointed, covered sparsely with fine hairs, and bearing two very long blackish marginal bristles. Wings hyaline, brownish ; i radial vein thick, not extending one third along the anterior margin, with a thick transverse vein near the base ; 2+3 radial vein very short, thick, divided from the apical portion of 4+5 radial vein ; 4+5 radial vein thick, extending from the hind portion of the base of the transverse vein of i radial vein to nearly the middle of the anterior margin ; costal vein very thick, reaching to the end of the 4+5 radial vein and bearing setae; i+2 medial vein arising from 4+5 radial vein at the hind portion of the divided point of 2+3 radial vein ; 3 medial vein arising at the middle of 3+5 radial vein ; cubital vein placed between 3 medial vein and posterior intercalary, and with a fine transverse veinlet at the basal one fourth portion ; anal vein distinct at the base, placed

near posterior intercalary. *Legs* long and somewhat stout, bearing fine hairs; pale yellowish brown, pale towards the base; coxae strongly thickened; femur compressed, broad tibiae with a long spine at the apical lower edge, except for the anterior tibia; tarsi with two fine spines at the apical edge of each joint; blackish brown, except for the anterior tarsi; claws rather small.

*Abdomen* rather slender, a little shorter than the head and thorax united, six segments visible; the dorsal surface blackish brown and the ventral surface yellowish; narrowed towards the apex.

Length about 1 mm.

**Larva.**

Milky white, somewhat flat, oval, elongate, somewhat curved backwards and the ventral surface nearly flat and straight, bearing sparsely fine hairs on the dorsal and lateral surface. Length of the full grown larva 2 mm.

**(ii). Life history.**

It has often been noticed by farmers and a few students that this fly is certainly a parasite of the larva of "Itten-O-Meiga" and *Chilo simplex*, but it is still doubtful whether it is parasitic or predaceous, although it has been reared from the larva of "Itten-O-Meiga". Usually this species is found in the neighbourhood of the dead larvae of *Schoenobius incertellus*, and its habitation is always in the inside of paddy stem which is injured by paddy Pyralids. Only once have I observed them feeding in a living larva, in great numbers; however, this fly probably feeds in several kinds of decaying substances, or in half dead larvae. The maggot always lives inside the paddy stem, about twenty or thirty together and it pupates in the same place. The pupa is pale yellowish white, flattened, and oval in shape. About ten days after pupation the fly emerges.

**2. Percentage of Larvae of "Itten-O-Meiga" which parasitised by each Parasite.**



Many observations were made to ascertain the percentage of the larvae of *Schoenobius incertellus* which parasitised by different enemies. In these observations, the larvae living in the stem were bred separately in glass tubes, and the parasitic imagos emerging were counted. The appended table summarizes the results:—

**Table XXXII.** Percentage of Larvae (Itten-O-Meiga) parasitised by different parasites.

| Year | Locality | Date. | Number of larvae examined. | Number of the parasites emerging from the larvae of "Itten-O-Meiga". | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Hymenoptera. | | Diptera. | | Gordius. | |
| | | | | Number of imagos emerged. | Percentage of larvae which parasitised. | Number of imagos emerged. | Percentage of larvae which attacked. | Number of emerged. | Percentage of larvae which parasitised. |
| | | | | | % | | % | | % |
| 1909 | Taihoku | 20. Jun. to 28. Jun. | 145 | 6 | 4.14 | 47 | 1.38 | 0 | 0 |
| | | 16. Jul. to 20. Jul. | 21 | 1 | 4.76 | 0 | 0 | 2 | 9.52 |
| | | 4. Nov. to 8. Nov. | 148 | 19 | 12.84 | 0 | 0 | 2 | 1.35 |
| | Taichiu | 15. Jun. to 30. Jun. | 100 | 1 | 100.00 | 0 | 0 | 0 | 0 |
| | | 1. Nov. to 15. Nov. | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Hozan | 10. Nov. to 30. Nov. | 200 | 8 | 4.00 | 0 | 0 | 0 | 0 |
| 1910 | Taihoku | 29. Oct. | 62 | 3 | 4.84 | 0 | 0 | 0 | 0 |
| | | 7. Nov. | 88 | 16 | 18.18 | 0 | 0 | 0 | 0 |
| | | 8. Nov. | 70 | 1 | 1.43 | 0 | 0 | 0 | 0 |
| | | 25. Jun. | 107 | 3 | 2.80 | 0 | 0 | 0 | 0 |
| | | 6. Jul. | 24 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Taichiu | 26. May. | 200 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30. Nov. | 200 | 2 | 1.00 | 0 | 0 | 0 | 0 |
| | Hozan | 17. Jun. | 200 | 6 | 3.00 | 0 | 0 | 0 | 0 |

| Year | Locality | Date. | Number of larvae examined. | Number of Hymenoptera emerged from the larvae of "Itten-O-Meiga". | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Eripternim schoenobii.* | | *Shirakia dorsalis.* | | *Amyosoma chilonis.* | | *Stenobracon maculata.* | | *Apanteles simplicis.* | |
| | | | | Number | Percentage | Number | Percentage | Number | Percentage | Number | Percentage | Number | Percentage |
| 1910 | Taihoku | I. crop. | 131 | 2 | 1.52 % | 1 | 0.76 % | 0 | 0 % | 0 | 0 % | 0 | 0 |
| | | II. crop. | 220 | 4 | 1.82 | 14 | 7.00 | 2 | 0.99 | 0 | 0 | 0 | 0 |
| | Taichu | I. crop. | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | II. crop. | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1.00 | 0 | 0 |
| | Hozan | I. crop. | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 3.00 |
| 1911 | Taihoku | I. crop. | 118 | 8 | 6.78 | 1 | 0.85 | 4 | 3.39 | 0 | 0 | 0 | 0 |
| | | II. crop. | 120 | 2 | 1.67 | 8 | 6.67 | 1 | 0.83 | 0 | 0 | 0 | 0 |
| | Taichu | I. crop. | 300 | 0 | 0 | 3 | 1.00 | 6 | 2.00 | 1 | 0.33 | 0 | 0 |
| | | II. crop. | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4.00 |
| | Hozan | I. crop. | 49 | 5 | 10.20 | 5 | 10.20 | 0 | 0 | 0 | 0 | 0 | 0 |

According to the above table it seems that some of the species of parasites do not occur in certain localities, but almost all those mentioned above occur practically throughout the Island. The following list shows in detail data concerning each of the parasitic Hymenoptera.

**(i) Eripternimorpha schoenobii** Vier.

This parasite occurs in the southern part more than in the other parts, and in the middle part less than in the others. On an average the percentage of the larvae of "Itten-O-Meiga" which destroyed by this species is probably three or four.

**(2) Shirakia dorsalis** Mats.

This is a most common parasite, and the degree of its occurence



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1911 | Taihoku | 21. Jun. | 101 | 7 | 6.93 | 0 | 0 | 6 | 4.95 |
| | | 26. Jun. | 17 | 6 | 35.29 | 0 | 0 | 0 | 0 |
| | | 3. Oct. | 45 | 2 | 4.65 | 0 | 0 | 2 | 4.65 |
| | | 18. Oct. | 35 | 6 | 17.14 | 0 | 0 | 0 | 0 |
| | | 24. Oct. | 38 | 3 | 9.37 | 0 | 0 | 0 | 0 |
| | Taichu | 7. May. | 200 | 1 | 0.50 | 0 | 0 | 0 | 0 |
| | | 1. Jun. | 100 | 9 | 9.00 | 0 | 0 | 0 | 0 |
| | | 16. Oct. | 100 | 4 | 4.00 | 0 | 0 | 0 | 0 |
| | Hozan | 7. Jun. | 49 | 10 | 20.41 | 0 | 0 | 8 | 16.33 |
| 1913 | Ako | 22. May. | 122 | 8 | 6.56 | 0 | 0 | 0 | 0 |
| | | 23. May. | 66 | 0 | 0 | 0 | 0 | 5 | 7.58 |
| | | 10. Jun. | 282 | 34 | 12.06 | 114 | 3.90 | 28 | 9.22 |
| | | 24. Jun. | 71 | 17 | 23.94 | 0 | 0 | 5 | 7.04 |

From the above data it is evident that practically 7.7 per cent of the larvae on an annual average are destroyed by the parasitic Hymenoptera; 0.22 per cent by Gordius, and 0.02 per cent by Diptera; that on the first crop the percentage of the larvae parasitised by the Hymenoptera in the northern parts is less than on the second crop, in the middle parts it is practically the same, and in the southern parts more; that on the first crop the percentage of the larvae destroyed by Gordius is more than on the second crop; and that the percentage of the larvae parasitised by the Hymenoptera in the northern parts is greater than in the other parts, and in the middle parts it is much less than in the others.

The following table shows clearly the percentage of the larvae parasitised by each species of the Hymenoptera:—

**Table XXXIII.** Percentage of "Itten-O-Meiga" which parasitised by different Hymenoptera.

is similar to that of the preceding species. The percentage is probably on an average three or four.

**(3) Amyosoma chilonis** Vier.

This species occurs less than the other two preceding species, and the degree of the occurrence diminishes gradually towards the southern part. The percentage is probably on an average one.

**(4) Stenobracon maculata** Mats.

This parasitic Hymenopteron very rarely attacks the larvae of "Itten-O-Meiga", it is commonly found in the southern part, and the percentage of the larvae destroyed by this species is on an average less than 0.3.

**(5) Apanteles simplicis** Vier.

This species is not known to attack the larvae of *Schoenobius incertellus* in the northern part, but it abundantly parasitises the larvae of *Chilo simplex*. In the middle and southern parts it occurs more abundantly than the preceding species (4), and the percentage of the larvae of "Itten-O-Meiga" which destroyed by this parasite is on an average about one.

**(6) Trath ? flavopedes** and **Eripternus? akoensis.**

These two species probably occur very rarely and the former has only occurred at Taihoku and the latter at Ako. The percentage of the larvae parasitised by these species is still unknown and is probably very small.

**3. Predaceous Insects.**

These include a number of species belonging to the orders Hymenoptera, Coleoptera, Diptera and Odonata. In the present report we shall only discuss a few species occurring commonly in the paddy field and attacking the larvae of "Itten-O-Meiga".

**a. Kiashi-Kuro-Himebai.** (pl. XX, figs 5-12;.

**Anatrichus erinaceous** Loew, Act. Acad. R. Suec. Consp., XVII, p. 95 (1860).

This minute fly belongs to the Subfamily *Oscininae* of the Family



*Chloropidae* (Diptera), and it is commonly known by farmers to attack the larvae of Paddy Pyralids.

**(i). Description.**

Adult black. *Head* nearly as broad as the thorax, shorter than the width, polished; the frons oblique, flat, seen from in front somewhat triangular, near the eye margin pale reddish brown, rugose and bearing sparsely yellowish, fine hairs; between the mouth parts and the antennal fossae blackish brown and broad, with a longitudinal carina at the sides; slightly concave in the middle, the apical edge with a distinct transverse carina. Proboscis short, stramineous, very narrow and cylindrical. Antennae strongly flattened, somewhat circular, the basal half yellowish brown, the upper half blackish brown, only two joints visible; near the outer edge of the apical end a slender dark brown seta which bears sparsely fine hairs. Eyes large, brownish black, placed on the sides of the head, the frontal margins parallel. Ocelli black, placed nearly touching one another on the vertex.

*Thorax* large, nearly three times as long as the head, slightly gibbose, bearing sparsely black-tipped, greyish white, long setae. Scutellum very large, triangular, extending to the middle of the first dorsal abdominal segment, covered closely with yellowish setae.

*Wings* hyaline, iridescent, bearing sparsely fine hairs, moderately large, the outer margin round, the veins pale yellow, with a row of short bristles on the costal margin; subcostal vein reaching to one third the basal portion of the anterior margin; radial vein extending from the middle of the subcostal vein to two thirds along the anterior margin; cubital vein divided from the radial vein before the end of the subcostal vein, and reaching to the apex of the anterior margin; medial vein with a transverse vein which reaches to the apex of the subcostal vein; postical vain at the base touching the medial vein and at the same distance from the base of the wing as the radial vein, connected with medial vein by a transverse vein; an anal vein

wanting. Halteres small, pale yellowish white. Legs moderate, rather slender, yellowish, brown towards the apex, bearing sparsely fine hairs; tarsi pale brown, 5-jointed, the first joint slender, more than twice the length of the other joints, the fourth shortest, the apical joint rather broad and blackish brown, the fore tarsi wholly blackish brown; the hind tibiae with a black longitudinal spot at the outer side of the middle; claws two in number, a little shorter than the apical tarsal joint, somewhat curved

*Abdomen* wider than the other parts, gibbose, the apical margin round; on the dorsal surface two distinct segments, the first of which is small and prolonged in the middle of the apical edge, the face rather rugose, bearing sparsely fine bristles.

Length 2.1 mm.

**Larva.**

Cylindrical, broadened toward the anal end; milky white but pale yellow in the middle part. Head very small, at the anterior margin two antennae which are three-jointed, 0.0182 mm. in length; the first segment of the body at the sides with a pale yellow respiratory organ which is divided at the apex into eight small flattened protuberances, 0.055 mm. in length and 0.064 mm. in width. The body bears on each lateral surfaces a longitudinal carina, and on the ventral surface on each segment below the fourth a transverse elevation. The anal end with a flattened, bottle-shaped process at the sides, this appendage 0.067 mm. in length and 0.077 mm. in width, and with the respiratory organ capable of free expansion and contraction. Length of full grown larva about 4.6 mm.

**Pupa.**

Dark reddish brown, the dorsal surface slightly convex, the ventral surface flat. The thorax with many transverse folds on the back; the head very flat, oblique, the first dorsal abdominal segment broadened at the anterior margin and with a rather large respiratory organ on the anterior angles; the anal segment very short, flat, with



very small scattered protuberances, and with two anal processes at the apex; these processes bear fine teeth at the lateral margin, and a protuberance medianly at the end; the segment immediately preceding the anal one with many parallel fine carinae, near the base of the middle a curved transverse carina; the remaining dorsal abdominal segments glabrous, with a few transverse folds near the joint.

Length 3.2 mm., width 0.7 mm.

**(ii) Life history.**

This dipterous maggot lives in the inside of the paddy stem, about ten together, and feeds on the larva of "Itten-O-Meiga" in stage IV or V. The maggot always attacks the outside of the larval skin. It is usually found in damp places, and it is unkown whether it prefers living or dead larvae. The full grown maggot pupates on the surrounding wall of the larva and emerges after two or three days. The fly is commonly found in abundance in the paddy bed and in the field also; until the year 1912 it was known generally as a parasitic fly of paddy Pyralids. It is, however, not a truly parasitic, but rather a predaceous fly. This species have been recorded by Prof. Bezzi from Africa and Ceylon.

**b. A Diptera.**

In the paddy fields of Formosa there is another fly, which feeds on the larva, from the outside of the skin. The imago has not yet been bred out. It has often been observed that the maggot feeds on the larvae in stage V, and it eats the whole body, leaving the head; and that it also eats the tissue of the paddy stem. It is always found in a very damp place in the stem. When the maggot finds the larva of "Itten-O-Meiga" it eats it up in about twenty minutes.

**Description.**

**Larva** subhyaline, slender, cylindrical, pointed at both ends. Head rather slender, the first segment always concealed; mouth parts pale brown, prolonged forwards; the body with two very hard longitudinal

blackish brown carinae on the dorsal surface; on each segment of the body many fine longitudinal sulci; on the anterior margin of each segment two sinuated transverse carinae; on the lateral surface a protuberance, and on each ventral segment two protuberance, excepting the first, second, third and anal segments which are without protuberance or transverse carina.

It is probably not an effective enemy of the larvae of "Itten-O-Meiga", and probably belongs to the Family, *Tabanidae*.

### c. Aoba-Arigata-Hanekakushi. (pl. XI, fig. 6.)

**Paederus idae** Lewis, Trans. Ent. Soc. Lond., p. 75, 1874.

This small insect belongs to the Family, *Staphylinidae* (*Coleoptera*), and is a very common species in the paddy field in Formosa, China and southern parts of Japan.

#### (i) Description.

Small, flat. *Head* black, polished, very flat, as long as wide, furnished with fine hairs, distinctly and very sparingly punctate; vertex slightly convex, nearly impunctate; mouth parts pale yellowish brown, broad, well developed; clypeus sparsely furnished with setae, the basal margin with a low protuberance at the lateral edges, this protuberance bearing a long seta; mandibles pale yellowish brown, the end sharp, strongly curved inwards. Eyes black, moderately projecting toward the sides of the head. Antennae slender, inserted nearly at the apical margin of the head, which is strongly prominent, 11-jointed, pale brown, paler towards the base, sparsely furnished with fine hairs, and with a few setae near the apex of each joint; the basal joint longest, with the base pale testaceus; the second clavate; the fourth a little longer than the second; the remaining joints shorter than the third, broadened toward the apex.

*Pronotum* somewhat ovate, about as broad as the head, reddish yellow, shining, very sparsely furnished with fine hairs, the punctuation distinct, except on the middle where is nearly impunctate, the anterior margin half as wide as the posterior margin, both margins



margined; scutellum very small, yellowish brown, bearing fine hairs, somewhat roundish, rugose above. Elytra short but distinctly longer than the pronotum, rectangular, dark blue, strongly punctate, sparsely pilose. Legs thin, testaceous, rather densely furnished with fine hairs, each joint fuscate, especially on the hind legs; tarsi 5-jointed, very often fuscate, the apical joint narrowest and with two claws.

*Abdomen* slender, not concealed under elytra, pale yellowish red-brown except for the two apical segments which are blackish, bearing sparsely brown hairs, densely on the two apical segments, the joints narrowest at the junctions, with a transverse sulcus near the anterior margin of each dorsal segment; pygidium long, somewhat triangular, with long hairy cerci.

Length 5.1 — 5.6 mm.

#### (ii) Life history.

Complete life cycle is still unknown. The adult has been repeatedly observed feeding on the larvae of "Itten-O-Meiga" in all stages. This small beetle is especially abundent in the paddy fields after the reaping, and is often seen frequenting growing plants also. It crawls into the paddy stem from the emergence hole which has been bored by the larva of "Itten-O-Meiga" and feeds on the larva; very rarely the beetle has been seen to capture the larva at the removing time. When there is irrigation water in the field, it removes from one stool to another by means of various floating substances, but such cases are very rare. A special count was made at Ako, and Taihoku (Formosa) on the second crop to ascertain the probable proportion of the larvae of "Itten-O-Meiga" which destroyed by this beetle. The hibernating larvae of *Schoenobius incertellus* on ten different stumps were examined, and on an average 65 per cent of the larvae were found to be attacked. It is probable that most of these gnawed larvae had been attacked by the *Paederus*, which were numerous in the field; and there were no other predaceous insects. This is no doubt an exceptional case, but it serves to show of what

great value this beetle may be under favourable conditions. The *Paederus* are usually found more abundantly in dry than in moist fields.

### d. Kuroashi-Aoba-Arigata-Hanekakushi.

**Paederus mixtus** Sharp, Trans. Ent. Soc. Lond., p 75, 1874.

A little larger than *P. idae*. Head and elytra very dark blue; two apical segments of the abdomen and legs black; thorax and the remaining abdominal segments reddish brown. *Head* as broad as long, coarsely punctate above, sparsely furnished with pale brown hairs; eyes comparatively large, black, placed nearly in the middle of the sides, prominent; antennae slightly longer than the head and thorax united, black, the three basal joints yellowish, but more or less infuscate; mandibles pitchy yellow, with a black outer margin. *Thorax* a little longer than broad, distinctly narrowed behind, the punctuation distinct except along the middle, where is impunctate. Elytra distinctly longer than the pronotum, the pubescence whitish, the puncturation moderately strong. Length 5.2 — 5.9 mm.

This species is abundantly found, with the preceding *Paederus*, in Formosa and China. The life history is the same as that of *P. idae*.

### e. Taiwan-Himeari. (pl. XI, fig.5).

**Tetramorium guineense** Fabr. (*Formica*), Ent Syst, II, p 357, 1793.

This insect belongs to the Subfamily *Myrmicinae* (*Formicidae*), and is rather a common ant in Formosa. The ant has been recorded from India, etc.

#### (i). Description.

☿. A little larger than Ako-Himeari. Head, thorax and pedicel pale yellowish brown; abdomen brown, paling at the extreme base and on the second and following segments, the apical margins of the abdominal segments yellowish; mandibles, antennae and legs dull red-



dish yellow; notum margined with blackish colour. Pilosity pale yellow, fine and fairly abundant, especially on the front of the head, oblique and very short on the scape of the antennae and the tibiae. *Head* somewhat flat, without the mandibles rectangular, half as long again as broad; lateral margins of the dorsal surface reddish brown; the dorsal surface longitudinally striate (6 or 8 striae), with some fine reticulations between the striae; mandibles smooth, slightly minutely punctured but not striate, the masticatory margin with one or two large teeth at apex, denticulate inwardly; clypeus longitudinally bicarinate in the middle, broad and somewhat convex; antennal carinae wide apart and produced slightly divergently back nearly to the top of the head, bordering a well-marked antennal groove, which is sculptured within like the rest of the head. Antennae 13-jointed, short and rather stout; the basal joint very small; scape longest, more than one-third of the whole length of antenna, falling short of the top of the head by about one-fourth its own length; pedicel as long as the first and second joints of flagellum united; flagellum clavate, the three basal joints nearly equal in length and very small, the following joints increasing gradually in length and width toward the tip, the apical joint largest and somewhat pointed. Eyes small, ovate, black, placed in the middle of the sides of the head.

*Thorax* distinctly narrower than the head, the front half of the dorsal surface broad and rounded and the posterior half narrow and rectangular, with reddish brown reticulated carinae; the sides vertical, margined above; pro-mesonotal suture moderately distinct above the thorax, incised at the sides at the suture; basal portion of metanotum narrow, short, the posterior lateral angles furnished with moderately long, oblique spines which are divergent and curved outward at the apex. Legs somewhat thick and short, pale yellow except for the base of each joint which is dark, the lower margin of tibiae bearing a pectinate spur near the apex.

*Abdomen*: Pedicel rather short, with large nodes which are somewhat

coarsely reticulate and rugose; the first node anteriorly petiolate, its face somewhat curved inwards, posteriorly roundly sloped; second node seen from above transversely globose, a little broader than long and much broader than the first node; the following abdominal segments united wider and longer than the head, the face smooth, polished and shining, with vestiges of minute longitudinal striae at the extreme base, convex, oval anteriorly, slightly truncate. Length 3.1 — 3.34 mm.

**(ii). Life history.**

The complete life history is not yet known. The worker feeds on the newly-hatched larvae of "Itten-O-Meiga", and sometimes crawls into the paddy stem from the entrance hole bored by the larvae and attacks the larvae of *Schoenobius incertellus* in stages IV and V. In the laboratory a number of the workers were kept in a large breeding cage, in which the larvae hatched from the eggs of "Itten-O-Meiga" were living. About three hours after this there were no larvae of the "Itten-O-Meiga". This is no doubt an exceptional case, but it serves to show of what great value the ants may be under favourable conditions. However, such favourable conditions are not always present, in irrigated fields, when the larva of "Itten-O-Meiga" is quite young, and the insect is probably less effective than *Paederus* and the following species.

**f. Ako-Himeari.**

There is another ant which attacks the larvae of "Itten-O-Meiga", that is Ako-Himeari (see Chapter VIII, I, H, 2). This is probably a most effective beneficial species, as a predaceous insects.

**4. Other Enemies.**

Among the natural enemies of the larvae of "Itten-O-Meiga" are several species of other insects; there are three species which are frequent in the paddy fields:— *Proreus simulans* Stal, *Ophionea cyanocephala* Fabr. and *Carabus* sp. These feed on the larvae hibernating in the rice stubble after the reaping of the second crop.



Among the natural enemies of other classes, the foremost is a kind of *Gordius*. During the rainy season of Formosa the larvae of "Itten-O-Meiga" are abundantly attacked by the *Gordius*, one or two of the species being often found in a single larva. The species is very slender and wire-like, it is usually two to thirteen inches in length, and pale yellowish white to pale grey in colour. It eats up the whole internal contents of the larva of "Itten-O-Meiga" and after this it leaves the host, boring a large irregular shaped hole through the ventral surface, between the fifth and eighth segments; later it begins to live freely in the water. According to several investigations it is known that the *Gordius* attacks the larvae of paddy *Pyralids* on the first crop than on the second crop; and than it is usually found in the larval body, when the rice field is flooded and the water penetrates into the paddy stem through the hole bored by the larva of "Itten-O-Meiga". Table XXXII shows the number of the larvae of "Itten O-Meiga" destroyed by the *Gordius* to be about 1.4 to 16.3 per cent on the first crop.

The second, a species of minute mite is a well-known beneficial *Acarine*, infesting various species of *Pyralids*. It is usually found on the skin of the larva in different stages, attacking in numbers varying one to about sixty. Although the percentage of the larvae of "Itten-O-Meiga" which attacked by the reddish yellow mites is, on an average during three years (1909-1911), 9.2%, it is probably that a number of the infested larvae do not die. The last, *Pyroderes formosanus* Mats., is a very well known beneficial creature, belonging to the Family *Attidae* (Arachnoidea). This species dexterously captures the removing or newly-hatched larvae of "Itten-O-Meiga". The *Pyroderes* deposits the eggs in nest which is webbed between the paddy leaves. The eggs are pale white in colour, very small, and round in shape, and usually about a hundred eggs are laid together in a web. The newly-hatched spider feeds on the larvae of "Itten-O-Meiga", especially when newly hatched. Although this spider is

not active, and an adult or young spider is not able to eat many larvae of *Schoenobius incertellus*, still it will be more effective than the mites.

In addition, it must be stated that there is a disease, the cause of which is unknown, which plays an important part in the economy of "Itten-O-Meiga". It is probably caused by *Bacteria*, (*Stolepto-coccus*), although its exact nature has not been clearly worked out. Its effects are most clearly apparent among larvae of rather large size. The appearance of a larva of "Itten-O-Meiga" after the disease is well advanced is characteristic. The body loses its firm consistency and becomes quite flabby, while the colour darkens to a greyish tinge. The larva loses the power of coordinated movement, only wriggling or twitching spasmodically when disturbed, and soon begins to turn darker. After its death it assumes a purplish black colour, and the whole internal contents liquefy more or less completely. When the skin is broken this liquid mass is seen to have a distinct reddish tinge, and it becomes darker as it dries.

Larvae hibernating in a very humid atmosphere seem to be more susceptible to the disease. During the year 1912 a number of the larvae of "Itten-O-Meiga" were collected at different periods in the growth of the paddy, to ascertain the probable percentage of the larvae destroyed by this disease. The following table shows the results and will give a general idea as to the percentage of larvae which destroyed by the disease:—

**Table XXXIV.** Percentage of larvae of "Itten-O-Meiga" which diseased, Formosa, 1912.

| Date when collected. | Locality | Different stages of paddy plant. | Number of larvae which collected. | Percentage of larvae which diseased. |
|---|---|---|---|---|
| | | | | % |
| 1. May. | Taihoku | Before shooting of the first crop. | 50 | 39.78 |
| 8. June. | do. | Reaping period of the first crop. | 35 | 14.32 |
| 15. October. | do. | Reaping period of the second crop. | 100 | 95.82 |



| | | | | |
|---|---|---|---|---|
| 4. July. | Taichiu | Reaping period of the first crop. | 100 | 8.77 |
| 3. June. | Hozan | Before reaping period of the first crop. | 100 | 43.03 |
| 21. Sept. | do. | Shooting period of the second crop. | 150 | 82.45 |
| 21. May. | Ako | Before reaping period of the first crop. | 200 | 69.29 |
| 31. October. | do. | Reaping period of the second crop. | 200 | 91.16 |

The great discrepancies in the different lots are in large part due to the amount of irrigation water present. Roughly speaking, however, the large percentages occur on the second crops, and it shows plainly that under certain conditions a great proportion may succumb to this malady.

In the laboratory, several cultures were made from a dried larva that had died from this disease. In all the cultures four species of *Bacteria* have found and they were mostly *Coccus*. Ten healthy larvae of "Itten-O-Meiga", which were in stage IV, were infested from the culture by pressing the mouth parts against the gelatine. Of the larvae thus infested, four died within five days with the sympoms of the bacterial disease; the others appeared to be unaffected.

In short, the natural enemies of the larvae of "Itten-O-Meiga" are practically abundant in the rice fields of Formosa, but of these, it seems that the malady is most effective; next to these the parasitic creatures; and the predaceous enemies are the least effective. In other countries, it has not been noted by any student whether enemies of the larvae occur.

## III. Pupa. (pl. II, fig. 6-7 and pl. VII, fig. 1-5).

### A. Description.

When newly emerged pale greenish white, eyes pale, straminеous; thorax pale yellowish and subhyaline; abdomen pale greenish, the apical abdominal segment pale white, the stigma yellowish brown. After one or two days the eyes become black, the abdomen loses its greenish colour; one day after this the body generally becomes

pale yellowish in colour, with the terminal abdominal segment white; after one or two days the eyes become greyish brown; pale reddish brown colour seen through the back of the thorax; after two or three days antennae become black; the two basal dorsal abdominal segments and legs seen through the pupal skin pale reddish brown, the apical abdominal segment always pale, but in the female rather dark grey. About a week after pupation the imago is seen through the pupal skin; a space appears between the pupal skin and the imago; many folds appear on the skin; it becomes a greyish silvery colour, and all the colouration of the moth is visible through the pupal skin.

Slender, somewhat spindle-shaped. *Head* small, slightly narrowed toward the apex, the ventral face horizontal, the dorsal face slightly gibbose and oblique; eyes placed on the ventral sides of the basal part of the head; antennae slender, extending to the end of the second joint of the mid tarsi, along and between the mid and hind tibiae, but in the female reaching to the end of the mid tibiae; labial palpi rather long and pointed, not reaching the apex of the fore coxae. Prothorax narrow, placed between the antennae, somewhat rounded anteriorly; collar transverse, curving forwards, with a longitudinal carina in the middle; tegulae developed irregularly in shape, placed on the base of the wings and at the dorsal lateral margin of the mesothorax. Mesothorax very narrow; the scutum and scutellum nearly equal in length; the former broad, round at the anterior margin, the posterior margin split in the middle, its lateral ends prolonged posteriorly, and with a line in the middle of the face; the latter large, prolonged posteriorly and the apex round. Metathorax a little wider than mesothorax, very short; scutum divided into two by mesoscutellum; scutellum placed along the middle line, the anterior and posterior margins curved posteriorly. Wing-sheath slender, broadened towards the apex; fore one round at the apex but the hind one



somewhat pointed; both reaching to the anterior margin of the fourth abdominal segment. Legs slender in the male the hind legs always extend further than the abdomen, rarely to the end of the abdomen, but in the female, to the apical edge of the sixth ventral abdominal segment. Abdomen in the male 10-segmented, but the three apical segments indistinct; the three segments narrow, somewhat conical but the apex slightly round, on the ventral surface a small narrow triangular depression, before this a transverse spot; in the female on the dorsal surface ten segments distinct; the four apical segments gibbose and thick, on the ventral surface the four apical segments united and with a broad, longitudinal elevation in the middle, the apical edge curved downwards.

Length :— male 10-11.5 mm.; female 11-13 mm.

### B. Process of Pupation. (pl. VIII. fig. 7.)

The larvae of "Itten-O-Meiga" feeding in the paddy stems enter as very small larvae, as already described, by eating down through the rolled-up leaves and between the leaf and stem. When they are completely grown no opening for the exit of the emerging adult is present, and the larva must bore its way out, directly through the stem, near the subterranean part or above it, before the pupation. After this, the larva crawls down the inside of the stem, and if there are nodes it bores through them. Upon the first crop and during the growing period of the second crop, it does not always crawl down to the lower part of the stem, and it stays in the stem near the water level, or very rarely, it crawls out of the stem and rests between the stem and the leaf.

Before a larva reaches such a place, it usually spins a few protecting membranes between the emergence hole of the adult and the pupating place. Once a larva has made all the above preparat-

ions, it begins to spin the pupal cocoon, which is cylindrical narrowed slightly toward the upper end, dirty white in colour, and 18-25 mm. in length. The time required to spin the cocoon varies anywhere between thirty minutes and twenty hours, or even much longer, depending on the activity of the larva and the external conditions. When it has spun the cocoon, the larva decreases in length, gradually approximating the length of the pupa, and at the same time becoming stouter in the middle and more tapering distally, the intersegmental constrictions growing more apparent, and it bends slightly backwards, keeping the head upwards. The colouring generally becomes less brilliant and tends towards a greyish yellow tint.

Later the larval skin splits medially along the dorsum of the thorax and the head of the pupa is passed through the opening, after which the skin is rather rapidly worked backwards by the movement of the body, finally forming a loose mass at the base of the cremaster, where it is easily thrown off entirely. This operation is accomplished in the extensive space of one or two hours or much longer.

Usually from twenty hours to two days are required for it to pupate after the spinning of the pupal cocoon, but during the hibernation it varies from ten days to a month or rarely much longer, depending chiefly on the amount of moisture in the soil.

## C. Length of the Pupal Stage.

The time passed in the cocoon after the larva has pupated until the moth emerges varies from four to eleven days in Formosa. In Japan, according to the reports of the different Agricultural Experiment Stations, it varies from eleven to twelve days at Fukuoka-Ken, Kiushiu, from twelve to twenty days at Kagawa Ken, Shikoku, and from eleven to seventeen days at Yehime-Ken, Shikoku,

Data collected at both the northern and southern parts of Formosa, for a hundred individuals in different broods, during four years, from 1908 to 1911, are summarized in the following table:—



**Table XXXV.** Length of the pupal stage, Formosa.

| Locality | Year | Average duration of pupal stage in different generations. | | | | | |
|---|---|---|---|---|---|---|---|
| | | First generation | Second generation | Third generation | Fourth generation | Fifth generation | Sixth generation |
| Taihoku | 1908 | 9.3 days | 8 days | 7.3 days | 4.1 days | 6.6 days | .... |
| | 1910 | 8.2 " | 7 " | 11 " | 7 " | .... | .... |
| | 1911 | 5 " | 5.2 " | 6 " | ? | .... | .... |
| Hozan | 1909 | ? | ? | 8 days | 5.5 days | 7.5 days | .... |
| Aio | 1911 | 6 days | ? | 6.3 days | 6 days | 8 days | 8 days |

This table shows that it is very hard to ascertain if there is a differentiation of length of the pupal stage in each brood of "Itten-O-Meiga", but probably, the differences are very slight.

## D. Effect of External Conditions.

In nature it seems as if the external conditions have not so close a relation with the life of the pupae, as with the larval life.

The influence of atmospheric temperature on the length of the pupal stage is not instructive or interesting, the pupa being apparently much less affected than the other stages.

On August 14th. 1912, at Taihoku, ten recently formed pupae were taken out of the cocoon and placed on a glass plate exposed to the direct rays of the sun for a week. It was, of course, necessary to keep them in a room during the night, and the pupae were examined every day. Eight emerged, and two which had pupated 24 hours before the beginning of the experiment were dead.

On 1st. February, 1913, at Taihoku, fifteen newly formed pupae were exposed to the cold air (11.2°-14.3° C.) without a cocoon, for a week. Twelve, two of which had pupated 24 hours before the experiment began, emerged satisfactorily five days after the termination of the exposure, and three, twenty-four hours old, were dead.

These results show that these coolings and heatings have no great effect on the pupae, excepting the quite newly formed ones, and that they make very little difference to the duration of the pupal stage But in the paddy field it does not frequently happen that the pupae are exposed directly to the air.

The effect of stubble burning on the hibernating pupae was tried during February, 1913, at Taihoku, Taichiu and Hozan. Fifty paddy stumps, well dried and standing in the field, were covered with rice straws and set on fire Soon after, the pupae were taken out of the remaining roots and were examined to see whether they were dead or alive ; all were found to be alive.

The moisture content of the soil does not seem to affect the life of the pupae. Of two paddy fields, in each of which forty nine stumps were standing in usual conditions, one was irrigated and the stubble submerged continually, while the other was left in its natural dry state, from the time when the larvae living under normal conditions have mostly pupated, until the replanting time (January-March), at Taihoku, Taichiu and Hozan. From both the fields there emerged many moths, and some of the pupae died in each case. All the dead pupae were found only in rotten or decayed stubble. This was due, no doubt, to the indirect effect of water and dryness on the pupal skin. In the irrigated field the emerging moths satisfactorily worked their way through the water for about four or five inches.

The effect of submergence under water was also tried upon pupae taken out of the cocoon, repeadedly during three years, from 1909 to 1911. At normal summer temperatures the pupae could not withstand one or two days' submergence ; but in winter the hibernating pupae were almost unharmed by such submergence, but could not withstand it over three days.

In nature, the pupae in rice stems or stumps are very often directly submerged and killed, by running water or heavy rain penetrating through the emergence hole, protecting membranes and cocoon.

In this case the pupae always assume a blackish brown tint and die.

The effect of farm methods is practically the same as that found in the larval stage; and it is also known that the kind of soil has no relation to the pupal life.

Natural enemies of the pupae are not known in any country. In Formosa, *Fripterniinorpha schoenobii* Viereck has been very often mistaken for a parasite of the pupa; but at the present time it is well known that there is no parasite. During the winter it is often observed that the hibernating pupae are destroyed by earwigs and ants, in small numbers, as is the case in the larval stage. When ducks and domestic fowls are freely kept in the paddy fields after reaping, a number of the larvae and pupae are destroyed by them. During the winter, it is commonly noticed that various birds frequently destroy the hibernating pupae and larvae of "Itten O-Meiga", but not in a large percentage.

Although no disease has yet been found in the pupae, it is very rarely observed, that a small percentage of the pupae in different broods are killed by a quite unknown agency. This is probably a disease. The percentage killed, by unknown power, of the hibernating pupae was 7.33 at Ako, 1913, and 0.1 at Taihoku, 1912.

In short, the effect of external conditions is very slight on the pupal stage, and its application as a control is much more difficult than on the larval stage.

## IV. ADULT. (pl. II, fig. 8-11; pl. V; and pl. VI).

### A. Description.

**Female.**

**Head** yellowish brown, moderately large, the dorsum between the eyes somewhat square, covered with white or greyish white scales, which are arranged obliquely and forwards along the middle longitudinal line of the face, but on the sides of the posterior margin of the head inwards; the scales almost belong to types VII, VIII, IX and



XII in Plate VII, and are larger toward the anterior margin of the head; frons somewhat square between the eyes, covered with white or greyish white scales which are nearly the same in shape as those of the dorsum; below the antennal fossae two scale masses, which are formed from scales of types V, VIII, IX, XI, and XV, united to each other at tip, seen from the dorsum, triangularly prolonged forwards; this is the apex of the maxillary palpi. *Eyes* black, convex, seen from the side somewhat triangular and narrowed below, covering nearly the whole of the sides of the head; the distance on the dorsum nearly twice as great as on the beneath; not shining; with small, radiated scales on the margins. *Antennae* small, filiform, 4.5 to 5 mm. in length, pointed; the ventral half dark brown and bearing sparsely fine hairs; the dorsal half covered with slightly shining small, white scales, in shape resembling types XX to XXII; 37-jointed, with a very fine spine on the apical edge of the dorsum of each joint (this spine only seen under a microscope); the first joint largest; the second nearly as long as the sixth but thicker; the third nearly as long as the fifth and shorter than the fourth; the sixth smallest and 0.0636 mm. in length; the following joints nearly equal in length, the apical joint 0.182 mm. in length, and with a seta 0.0455 mm in length, at the end. *Labial palpi* rather slender, 3 to 3.2 mm. in length horizontally prolonged forwards, covered densely with pale yellowish grey-white or greyish white scales, which are of types II, IV, VIII and XII in shape; three-jointed. Seen with the scales removed, the first joint short and thick, less than half the length of the third, pale yellow; the second more than twice the length of the third, thickest, somewhat compressed, curving ventrally, blackish; the third yellowish, spindle-shaped, thinner than the preceding joints. Length of labial palpi with the scales removed:— the first joint 0.19696 — 0.27272 mm.; the second 1.0606 — 1.40909 mm.; the third 0.37878 — 0.46969 mm. *Rostrum* very small, pale yellow, concealed between the labial palpi, rudimentary; 0.8364 — 0.91212 m.m. in length, 0.063737 — 0.06909

mm. in width. *Maxillary palpi* small, three-jointed, covered densely with white or yellowish grey-white, somewhat oblique upwards; the first joint about 0.4545 mm. in length, very small; the second largest, curving, slightly outwards, about 0.15454 mm. in length; the third about 0.25454 mm. in length. *Labrum* very short, knobbed at the sides of the joint between the labrum and the clypeus; pharynx somewhat long triangular, placed at the base of the rostrum, 0.04545-0.046393 mm. in length.

**Thorax.** Moderately large, covered densely with white or yellowish grey-white scales and hairs. *Prothorax* very small, invisible; collar transverse, broadened in the middle, pale yellowish brown, covered densely with scales which are exactly the same colour as those of the thorax, the anterior edge somewhat straight, the lateral margins round, its scales belonging to types XII, XV, XXI and XXIV in shape; pronotum, seen from the dorsum very short; pleurae rather big, larger than the other parts of the prothorax; the sternum forming the posterior margin of the prothoracic cavity, consisting of two pieces, the fore part distinctly convex, the hind part inconspicuous, bearing the coxae of the fore legs. *Mesothorax*:- Broad, largest, yellowish brown, the dorsum covered densely with greyish white or pale yellowish grey white scales of types IV, V, XII, XXI and XXIII in shape; notum large, formed from both the somewhat heart-shaped scutum and triangular scutellum, the former strongly convex and with a fine, longitudinal sulcus in the middle, the latter slightly convex; tegulae large, extending from the base of the wing to the apical two-thirds of the scutum, the apex round and narrower than at the base, pale stramineous, covered densely with yellowish grey-white, or very rarely, greyish white long scales, which are placed on the apex, reaching further than the apex of the scutum; postpleurae slender, angular at the apex, a little wider than the praepleurae; the scales of mesothorax the same as those of the legs. *Metathorax*:- Smaller than mesothorax; broader than the length, but narrower than the



mesothorax; the colouring and shape of the scales the same as in the mesothorax; scutum very short, transverse, strongly shortened in the middle; scutellum somewhat triangular, the apex somewhat round, slightly convex with scutum, which seen from the side is irregularly pentagonal and the lower margin wider than the upper edge; praepleurae slender, almost always narrower than the mesopraepleurae, or very rarely wider; postpleurae wider than the mesopostpleurae, apparently triangular, shorter than praepleurae.

**Wings.** Moderately large. *Forewings* long, the costal margin very slightly curved outwards, the outer margin apparently curved outwards, the inner margin somewhat sinuate, the anterior angle narrow but not prolonged, the outer angle round. The surface covered densely with pale orange-yellowish white scales (types V, VII, X, XIII, XIV and XV), which are paler on the base than on the apex; on the posterior angle of discoidal cell a black spot which agrees with the scales of types XIII and XIV in shape, and extends between the base of the 4th., 5th., and 6th. veins. The marginal cilia on the inner margin slender, pale, consisting of scales of about 0.7575 mm. long of types I and IV in shape, and which on the outer margin consist of two layers, one of them formed with scale-like orange yellow or orange yellowish white hairs, about 0.606 mm. long, and the other with scales about 0.303 mm. long. Veins well-developed; 1a. very short, distinct only at the base of wing, 1b. well-developed, nearly straight, reaching to slightly below the outer angle, 1c. absent; vein 2. arising at about two thirds along the posterior margin of discoidal cell, slightly curved outwards; vein 3. arised before the posterior angle of discoidal cell, nearly parallel with vein 2. and slightly curved in an S-shape, reaching to the outer margin and placed at one half of the distance between 1b. and 2.; veins 4. and 5. remote from one point of the posterior angle of discoidal cell, or free; the former in the middle between veins 3. and 5., very slightly curved to an S-shape, the latter slightly curved outwards; vein 6. nearer to vein 7. than to 5. at the

base, its distance from 5. being equal to the distance between veins 4. and 5 at the outer margin; vein 7. almost straight, nearer to 6. than to 8.; vein 8. reaching to the anterior angle, nearer to 7. than to 10. at the base; vein 9. separated from slightly after the middle of 8.; vein 10. separated from the cell before the base of vein 8., at the base approximated to 8.; vein 11. separated from about two thirds along the anterior margin of the cell, curved outwards, reaching to two thirds along the costal margin; vein 12. very slightly sinuated, much approximated to 11. near the apical end and connected to 11. by a bar, this bar sometimes absent or indistinct, after this diverted gradually from 11. and scarcely reaching to the costal margin (or only occasionally). *Hindwings* somewhat triangular, distinctly shorter than the forewings and broader; the costal margin distinctly curved inwards at the middle; the outer margin curved outwards except between veins 5. and 6., and reaching the point of vein 2. which is slightly curved inwards; the inner margin slightly sinuated; the anterior angle broader than in the forewing and round. The surface covered with scales, which are paler than those of the forewing, without spots, nearly concolorous. Marginal cilia pale yellowish grey-white, which on the outer margin are like those of the forewing, but the shorter one not distinctly formed of one layer; on the inner margin much longer than in the forewing. Veins rather thick; 1a., b., c. well developed, straight, slightly diverted from each other toward the ends; vein 2 separated from two thirds along the posterior margin of the discoidal cell, parallel with 1c., nearly straight; vein 3. arising just below the posterior angle of the cell, sometimes from the angle itself, slightly curved outwards, exactly equidistant form veins 2. and 4. at the outer margin of the wing; vein 4. straight; 5. nearer to 4 than to 6. at the outer margin of the wing, slightly curved inwards at the base; 6. and 7. with long or short stalk, or arising from a point at the anterior angle of the cell, very slightly sinuated, vein 6. nearer to 5. than to 7. at the end, distance between 6. and 7. at the end the same as



between 5. and 4., vein 7. reaching to the anterior angle of the wing. Frenurum fine, brown, 1.303-1.414 mm. in length.

Length of wings :- Forewing 10 3-13 mm.; hindwing 8 5-10 mm.

**Legs** slender, compressed and covered with scales of types VII, VIII, XV, XVIII, XIX and XXII. *Fore legs* shortest, almost covered with greyish white scales, but on the inner side darker; tibiae and the first tarsal joint paler than the others; femur, coxae, and the fifth tarsal joint darker than the others; tibia just below the middle of the lower inner margin bearing a spur with a straight fine spine; tarsi 5-jointed, the fourth joint shortest bearing on the lower surface of each joint two or three pairs of hairs, the fifth joint with two claws at the apex and an empodium which is somewhat rugose, roundish, narrowed below; the claw at the base thick, narrowed toward the tip and pointed; the apical joint of tarsi with two long hairs almost like bristles, at the end of the lower margin. Length of the fore legs :- coxae, 1.2424-1.2727 mm.; trochanters, 0.24242-0.22727 mm.; femur, 1.8182-1.8473 mm.; tibiae, 0.8182-0.8333 mm.; first tarsal joint, 1.0303-1.0606 mm.; second tarsal joint, 0.3636-0.4242 mm.; third tarsal joint, 0.2727-0.303 mm.; fourth tarsal joint, 0.2121-0.2273 mm.; fifth tarsal joint 0.2424-0.2576 mm.; spur, 0.31-0.31182 mm. *Mid legs* very slender, covered densely with greyish white scales, the inner surface somewhat darker; tarsi on the outer surface darkened toward the apex, and on the inner surface slightly fading to a yellowish grey-white tint; tibiae with two spurs on the lower end, the inner one of which is longer than the outer, and curved at the end, the outer spur nearly straight, these spurs smooth at the end, yellow and without scales, but the other part rather rugose, with scales; each tarsal joint dark at the upper edge of the apex. Length :- coxae, 1.212-1.3636 mm.; trochanters, 0.22727-0.30303 mm.; femur, 2-2.121 mm.; tibiae, 1.6363-2.2727 mm.; inner tibial spur, 0.6667-0.7575 mm.; outer tibial spur, 0.2424-0.333 mm.; first tarsal joint, 1.13636-1.3939 mm.; second tarsal joint, 0.51515-0.60606 mm.; third tarsal joint, 0.37879-0.45455 mm.; fourth tarsal

joints, 0.28788-0.36364 mm.; fifth tarsal joints, 0.27273-0.30303 mm. *Hind legs* like the mid legs, but differing chiefly as follows:- Tibiae with two pairs of spurs, the basal spurs at slightly below the middle of the lower margin, where it is narrowed, having a transverse line. Length:- coxae, 1.2121-1.2424 mm.; trochanters, 0.2727-0.2879 mm.; femur, 1.7273-1.9697 mm.; tibiae, 3.0909-3.7273 mm.; basal inner spurs, 0.8636-1 mm.; basal outer spurs, 0.4848-0.5606 mm.; apical inner spurs, 0.6969-0.7576 mm.; apical outer spurs, 0.4091-0.4545 mm.; first tarsal joints, 1.2424-1.5909 mm.; second tarsal joints, 0.6969-0.9545 mm.; third tarsal joints, 0.5151-0.7273 mm.; fourth tarsal joints, 0.3636-0.5151 mm.; fifth tarsal joints, 0.2879-0.4091 mm.

**Abdomen.** Yellowish brown, long and thick, longer than the inner margin of the hind wing, covered with scales of types IV-XI; the dorsum covered densely with shining white scales and short pale yellowish grey scales, the latter always fall off when the moth emerges from the pupal skin, except those on the first dorsal abdominal segment. Length, 8-8.8 mm. *Dorsum*:- Seven distinct segments; first segment very small, as wide as the metascutellum, very short and transverse, flat, the posterior margin somewhat obtuse, with a depression, the lateral margine slightly curved outwards; second segment a little longer than the first, the posterior and lateral margins somewhat curved inwards; third segment shorter than the second but longer than the fourth, the posterior margin curved inward and the lateral margins curved outwards, as also in the fourth segment; fifth segment nearly as large as the third, the posterior and lateral margins slightly curved outwards; sixth segment shorter than the fifth, broadest, the posterior margin apparently curved inwards; seventh segment blackish brown, convex, the posterior margin round, with the sixth, covered densely with dark greyish brown rather short hairs, the joint between the sixth and seventh segments bearing densely greyish white hairs about 1.6-2 mm. long. *Sides*:- Narrow, six distinct segments, the scales the same in shape as those on the dorsum, and greyish



white, without yellowish brown scales, the scales at the posterior margin of each segment longer than the others and obliquely prolonged laterally; the sixth segment very small, somewhat triangular, not connected with the sixth ventral segment, the upper margin slightly rounded, the lower margin nearly straight, narrowed toward the apex, bearing densely greyish white hairs like the sixth ventral segment. *Venter*:- Six distinct segments, the anterior margin of the first segment strongly curved inwards, the posterior margin of each segment more or less curved outwards; the sixth segment smallest, somewhat semi-circular, rounded at the apex, bearing rather long hairs; the sides of this segment covered with oblique hairs like the sixth lateral segment. *Genital parts*:- Genital organ mostly concealed under the seventh dorsal abdominal segment; its tip somewhat exserted from the round hole below the seventh abdonimal segment; suranal plate somewhat large, about 0.545 mm. in width, and about 0.515 mm. in length, nearly cylindrical, hut not closed at the venter, seen from the lateral side the apex truncated obliquely, the lower margin much narrower than the upper margin, the apical edge bearing a few fine hairs; subgenital plate brown, placed on the venter, about 0.243 mm. in length, and about 0.515 mm. in width, somewhat semicircular, the posterior margin round, somewhat concealing the ventral basal part of the suranal plate, which is also brown; ovipositor somewhat conical, slightly exserted ventrally beyond the anal tufts, the ventral surface with a keel, which opens longitudinally, the surface rugose, covered with long hairs, about 0.606 mm. in length, the base about 6.364 mm. in width.

**Male.**

Usualley smaller than the female.

**Head** rather large, the dorsum between the eyes small, somewhat longer than the width, covered with greyish stramineous scales, the arrangement of these the same as in the female, the scales of the apex much longer than those of the female, but not reaching further than

the tip of the scales of the labial palpi. *Eyes* rather large, about 5.6 mm. in longitudinal diameter, moderately convex, somewhat semi-circular, seen from the lateral side the posterior margin nearly straight, bearing radially at the margins short scales, but not distinct as those of the female, the diameter between the inner margins of the eyes nearly equal to the width of the eyes, in dorsal view. *Antennae* 46-jointed, somewhat setaceous, bearing white scales on the dorsum, the venter covered densely with dark brown fine hairs, which are a little shorter than the width of each antennal joint, and the direction of the hairs not so oblique as in the female; the first joint large, somewhat globular, about 0.266 mm. in length, and about 0.2273 mm. in width; the second segment about 0.091 mm. in length and about 0.1364 mm. in width, shorter than the third but wider, nearly one third as long as the first; the two basal joints not bearing hairs but covered with scales, the scales of the following joints in two transverse rows on each joint; the apical joint about 0.1364 mm. in length, pointed, at the tip a spine which bears no hairs or scales, and is about 0.121 mm. long; the apical eight or nine joints longer than wide, the apical edge of each joint strongly oblique towards the tip, the joint immediately preceding this always longer than the one before it. *Maxillary palpi* darker than in the female, 3-jointed; the scales slender, almost always longer than the second joint, greyish yellow brown, those on the inner and dorsal surfaces paler than the others; the first segment about 0.064 mm., the second about 0.155 mm., the third about 0.255 mm., in length. *Labial palpi* 3-jointed, the scales mingled with numerous hairs, mostly greyish brown, but the scales on the inner and dorsal surfaces of the palpi paler than the others, and the same in colour as those on the head. Length of the labial palpi:- first joint, 0.1212-0.2273 mm.; second joint, 1.2273-1.2576 mm.; third joint, 0.3939-0.4848 mm. *Rostrum* more degenerate than in the female, minute. The remaining parts the same essentially as in the female.



**Thorax**:- The same as in the female.

**Wings**:- Narrower than those of the female and more oblique. *Fore wings* covered with dirty grey scales, on the posterior angle of the discoidal cell a black spot which is much smaller than in the female; between vein 1b. and the posterior margin of discoidal cell three black spots in a longitudinal line, the middle spot placed in the middle of the diameter between the basal and apical spots, the apical spot in an imaginary line drawn from the posterior angle of discoidal cell and parallel to the outer margin of wing, the basal spot at just below one fourth along the posterior margin of discoidal cell, these three spots always distinct; the anterior margin of the cell with three indistinct small dark brown spots, the mid one of which is largest, the apical one small, black, and placed on the anterior angle of the cell, these spots sometimes wanted; an indistinct dark oblique band extending from just before the costal angle to a little below the posterior angle of the cell; along the outer margin of the wing nine small black spots in a row, the upper seven of these distinct and placed at the end of each vein, the following two very often indistinct, placed on vein 1b. and between veins 2. and 1b.; the scales of the surface pale greyish brown and dirty grey in colour; the marginal cilia essentially as in the female, mostly, dirty grey. The under surface dark brown, somewhat yellowish on the veins and the costal margin, the outer margin paler, the marginal spots present. *Hind wing* almost as in the female; the surface shining, pale yellowish grey white, the outer margin and the veins darker, on the apex of each vein an indistinct small dark spot; the marginal cilia the same in colour as the outer margin but the tip paler; the under surface slightly paler than the fore wing, paler toward the base, the outer marginal spots rather clearer than those on the surface; frenulum somewhat curved, about 1.212 mm. in length. Length of the wings:-fore wings, 9-10 mm.; hind wings, 7.5-8.2 mm.

**Legs**:- *Fore legs* shortest, essentially as in the female but differing

chiefly as follows :— The scales on the outer surface dark and on the inner surface greyish white ; the spur thick, somewhat yellowish, covered with very small scales, the inner lower margin bearing long scales, and with a small spine at the apex ; the tarsal joints bearing long scales of type XV on the apical lower edge. Length :— coxae, 1.0606—1.93 mm. ; femur, 1.4848—1.6969 mm. ; tibiae, 0.6667—0.8182 mm. ; spurs, 0.3636—0.5 mm. ; first tarsal joints, 1.0303—1.2121 mm. ; second tarsal joints, 0.4091—0.5 mm. ; third tarsal joints, 0.2727—0.3788 mm. ; fourth tarsal joints, 0.2273—0.303 mm. ; fifth tarsal joints, 0.1697—0.2424 mm. *Mid legs* as in the female, yellowish grey white, concolorous. Length :— coxae, 1.0606—1.2879 mm. ; femur, 1.8485—2 mm. ; tibiae, 1.8182—2.0606 mm. ; inner spurs, 0.4545—0.7273 mm. ; outer spurs, 0.2273—0.3636 mm. ; first tarsal joints, 1.1212—1.5151 mm. ; second tarsal joints, 0.5152—0.8333 mm. ; third tarsal joints, 0.3955—0.6667 mm. ; fourth tarsal joints, 0.3636—0.4818 mm. ; fifth tarsal joints, 0.2636—0.3485 mm. *Hind legs* as in the female but darker. Length :— coxae, 1.0303—1.2727 mm. ; femur, 1.4394—1.8182 mm. ; tibiae, 1.8485—3.5151 mm. ; basal inner spurs, 0.7576—0.9903 mm. ; basal outer spurs, 0.4242—0.7273 mm. ; apical inner spurs, 0.6667—0.8485 mm. ; apical outer spurs, 0.409—0.5758 mm. ; first tarsal joints 1.2727—1.6061 mm. ; second tarsal joints, 0.8424—1.1212 mm. ; third tarsal joints, 0.6667—1 mm. ; fourth tarsal joints, 0.4545—0.6667 mm. ; fifth tarsal joints, 0.2576—0.5 mm.

**Abdomen** smaller than in the female but much longer than the inner margin of the hind wing, the scales and hairs as in the female, anal tufts wanted. The dorsum 7-segmented ; the first segment flat ; the second segment more or less flat ; the third segment longest ; the fourth to fifth segments short, the latter much shorter than the seventh ; the seventh segment at the apex obtuse and somewhat prolonged, the lateral ends of the hind margin slightly prolonged posteriorly. The venter 6-segmented ; the sixth segment at the apical edge somewhat curved inwards, the curved margin in the middle blackish brown and



rugose, and with a large brush-like mass, which is about 0.4545 mm. in length and formed of hard brown scale-like setae ; subgenital plate small, somewhat triangular, concealed in the brush, about 0.15—1.5 mm. in length, in the middle of the surface a small brush, which is essentially like the brush on the sixth ventral abdominal segment, and about 0.2121 mm. in length ; suranal plate connected with subgenital plate by means of a thin, chitinous membrane. *Genital parts* :- Claspers large, placed on the lateral sides of the abdomen, the upper and lower edges somewhat straight, the latter shorter than the former, the apical edge oblique, round, the upper angle somewhat narrow, and the lower angle obtuse, both rounded, the margins of the clasper touching one another ; the surface covered with white scales of types I—V, the inside bearing very narrow scales near the apex only where there is also a slightly curved, chitinous carina. The claspers produced from the inside of the sixth ventral abdominal segment, and covered at one fourth the basal part by the apex of this segment. The hooks in two pairs, all placed on the inside of the clasper ; the first hooks on the lower base of the clasper, the tip divided into two spines, the inner spine short, about 0.1515 mm. in length and pale in colour, the outer spine long, about 0,2273 mm. in length and brown in colour ; the second hooks between the upper basal edge of the clasper and the base of the covers of the penis, curved inwards, divided into two spines at the tip, the posterior spine large, brown, much longer than the outer spine of the first hook, the anterior spine about half as long as the posterior spine, paler, the basal part of the second hooks more or less extended towards the upper edge of the clasper, thick and pale yellowish brown. There is another hook, having no connection with the claspers. This third hook, concealed between the claspers, except at the dorsal triangular base, is large, concealing the penis, the greater part divided into two hooks ; the hooks curved backwards at the base and triangular, the dorsal hook brown, the ventral hook, in the middle nearly colourless, membranous

and concave, at the base. This membranous portion chitinized towards the apex, and near the apex with a depression; the dorsal and ventral hooks strongly narrowed towards the tip to resemble a spine, the spine-like portion about 0.455 mm. in length; the dorsal one paler, slightly curved downwards, and bearing sparsely fine hairs, at the tip not pointed; the ventral hook curved backwards, dark reddish brown, pointed, and without hairs at the tip. Penis extending to the basal half of the spine-like portion of the third hook; the apex thick, divided laterally into two, the divided apex curved inwards, in the middle of these a small, irregular, triangular plate, between which is the opening of the ejaculatory duct; this small appendage bearing a small seta dorsally at the base.

## B. Emergence.

Under normal conditions the pupa, resting at the lower end of the inside of the subterranean paddy stem, or at the middle part of the stem, or very rarely between the stem and the leaf, splits the pupa-case along the median dorsal line of the thorax, and the moth escaping, with still unexpanded wings crawls up to the emergence hole, boring through the stem wall. Here it must break through the thin membrane spun by the larva before reaching the outside of the stem; and it must, of course, break one or two intermedial membranes on the way to the emergence hole. The moths seem to be very strong and have no trouble in breaking these membranes, making an aperture through which they accomplish their exit. The openings through the protection membranes are rather regular, margined with pale brown in tint. Once out, the moth is perfect, with the exception that the wings are unexpanded. After a few minutes, the wings have become extended to their full size, and about two or three hours later the moth is able to fly. If disturbed before the wings are strong enough for flight, the moths are very active, and can run about with



surprising agility.

There is a well-marked tendency among the moths to emerge during the night from about seven to nine o'clock. After nine o'clock the number of the emerging moths gradually decreases toward the morning; in the very early morning it increases again, and the emergence stops usually after sunrise.

The emergence period of the moths of different broods, of course, vary in different localities; this will now be discussed according to the numbers of the moths attracted by a light trap. A large number of observations were made in Japan and Formosa for several years. The following table summarizes the results:—

**Table XXXVI.** Seasons at which the moths of the different generations were most abundantly attracted to the light-trap, in Japan and Formosa.

| | Locality. | Transplanting period of paddy. | Seasons at which the moths of the different generation were most abundantly attracted to the light-trap. | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | First generat. | Second generat. | Third generat. | Fourth generat. | Fifth generat. | Sixth generat. |
| Japan. | Saga | E. C. 10-20. V.<br>L. C. 1-10. VII. | 20. V to 10. VI. | 10 to 31. VII. | 10 to 31. VIII. | .... | .... | .... |
| | Fukuoka | Middle crop, 10 to 30. VI. | 10-20. VI. | 10 to 20. VII. | 20. VIII to 10. XI. | .... | .... | .... |
| | Nagasaki | E. C. 10-20. VI.<br>M. C. 10-30. VI.<br>L. C. 20-30. VI. | 10 to 20. VI. | 20 to 31. VII. | 20 to 31. VIII. | .... | .... | .... |
| | Kumamoto | Late crop, 1 to 10. VI. | 20. V to 10. VI. | 10 to 30. VII. | 20 to 31. VIII. | .... | .... | .... |
| | Yanagawa | E. C. 1-10. VI.<br>L. C. 1-10. VII. | 20. V to 10. VI. | 10 to 20. VII. | 20. VIII to 10. IX. | .... | .... | . .. |
| | Miyazaki | E. C. 20-31. V.<br>M. C. 1-10. VI.<br>L. C. 10-20. VI. | 10 to 31. V. | 10 to 20. VII. | 10 to 31. VIII. | .... | .... | .... |
| | Yehime | E. C. 1-10. VI.<br>L. C. 1-20. VI. | 20. V to 10. VI. | 10 to 31. VII. | 1 to 10. IX. | .... | .... | .... |
| | Kagawa | | 20. V to 10. VI. | 20 to 31. VII. | 20. VIII to 10. IX. | .... | .... | .... |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Formosa. | Taihoku | F. C. III to IV.<br>S. C. 10. VII<br>to 10. VIII. | III | VI | VII | X | .... | .... |
| | Taichiu | F. C. II to III.<br>S. C. 20. VI<br>to 20. VIII. | III | V | VI | VII | IX | .... |
| | Hozan | F. C. I to II.<br>S. C. VI to VIII. | II | III | VI | VII | IX | X |

Note :— E.C.···Early crop ; M.C.···Middle crop ; L.C.·· Late crop ;
F.C.···First crop ; S.C.···Second crop.

This table shows that in Japan the moth emerges from May to September, and in Formosa from February to October ; and that in Formosa it does not emerge abundantly in August, notwithstanding that the weather is very hot ; this is probably to the fact that the pupae or larvae are destroyed by the reaping of the first crops. It shows also that the emergence-period of the early brood coincides with the transplantation time of the paddy plants ; and in Formosa, the replantation time of the second crops with that of the third or fourth broods. Although it seems as if the emergence is regulated by the appearance or non-appearance of the food-plants, it will be found that this is not so, and the emergence is only influenced by the temperature, as will at once be seen if we turn to Kanten-Den, where the moth of the early brood emerges in February, inspite of the fact that the paddy is replanted after May.

## C. Proportion of the Sexes.

Practically it is impossible to determine the proportion of the sexes emerging in the fields. However, the probable proportion can be ascertained according to the records of moths collected in the field by light traps, and of those bred out in the laboratory. During the last five years an extremely large number of the moths were captured by light traps in different localities in Formosa, and were examined. In practically all cases, there was a great preponderance of females, although at the beginning of each brood more males than females were captured, especially at the early brood. During 1912, in the



laboratory 123 moths were bred out from three egg-clusters, 22 of these were males and the rest were females. In this case, about twenty per cent of the moths bred out from an egg-cluster were males. In nature, there will be a rather considerable preponderance of females in the proportion of the sexes.

## D. Length of Life.

The life of the moths seems to be ascertain almost entirely by ease or difficulty of coupling, and not to be regulated by the supply of available food, although it is probably controlled by external conditions. As a rule, the females die about one day after their oviposition, and the males do not live so long as the females, notwithstanding that they live a few days after their several copulations. During the season a hundred moths were kept in breeding-cages in the laboratory and in a field, and subjected to variable conditions in order to ascertain the length of life. A summary of results is given in the table below :—

**Table XXXVII.** Length of moths, 1912, Taihoku.

| Month. | Female. | | | | | | | | | | | | Male. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | With food. | | | | | | Without food. | | | | | | With food. | | | Without food. | | |
| | Length of whole life. | | | Length of life after oviposit. | | | Length of whole life. | | | Length of life after oviposit. | | | Length of whole life. | | | Length of whole life. | | |
| | L. | S. | Av. | L. | S. | Av. | L. | S. | Av. | L. | S. | Av. | L. | S. | Av. | L. | S. | Av. |
| April | 15 | 6 | 8.7 | 3 | 1 | 1.1 | 13 | 6 | 8.8 | 4 | 1 | 1.2 | 16 | 5 | 7.8 | 13 | 2 | 8.6 |
| May | 12 | 5 | 8.1 | 3 | 1 | 1.5 | 13 | 5 | 8.2 | 3 | 1 | 1.8 | 11 | 3 | 6.7 | 15 | 4 | 5.9 |
| June | 10 | 6 | 7.7 | 5 | 1 | 1.7 | 9 | 6 | 7.6 | 3 | 1 | 1.9 | 7 | 3 | 4.5 | 8 | 4 | 5.5 |
| July | 10 | 3 | 5.3 | 3 | 1 | 1.1 | 11 | 2 | 5.4 | 4 | 1 | 1.2 | 11 | 3 | 5.1 | 9 | 4 | 5.6 |
| August | 8 | 4 | 5.7 | 4 | 1 | 1.3 | 10 | 5 | 6.7 | 5 | 1 | 1.4 | 10 | 4 | 6.8 | 8 | 5 | 5.9 |
| September | 12 | 4 | 6.6 | 3 | 1 | 1.8 | 10 | 3 | 5.9 | 4 | 1 | 1.9 | 9 | 5 | 5.8 | 10 | 3 | 6.8 |
| October | 11 | 5 | 8.3 | 5 | 1 | 1.5 | 8 | 7 | 7.7 | 3 | 1 | 1.8 | 9 | 7 | 8.1 | 17 | 5 | 7.9 |
| Japan # | 12 | 4 | 7 | 5 | 1 | 1.5 | | | | | | | 10 | 3 | 5.5 | | | |

Note :— L.··· longest ; S.··· shortest ; Av.··· average.

# see the Special Report of the Agricaltural Experiment station, Yehime-Ken, vol. II.

From this table it is apparent that the first generation is distinguished by its much longer life, and third generation by a much shorter duration.

## E. Habits.

### 1. Day Habits.

During the daytime the moth is usually very quite, resting on the sheath of the paddy leaf, where it is more or less concealed. The insects rest with the head up and the wings tightly folded down over the back. In this position they often remain during the entire day unless molested or frightened. A jarring of the plant, or any unusual disturbance, however, quickly awakens the resting moth, and hastly leaving the plant it flies wildly about until it chances upon another, where it quickly insinuated itself into the rolled-up leaves or between the sheath and the stem, by a series of zigzag forward movements. A few moments afterwards, when it has regained its composure, it crawls out from here to the surface of the sheath ; the wings are held somewhat apart and vibrate slightly. If again disturbed while this on the alert, the second flight is usually much longer and the moth will fly for about fifty feet or more before alighting. If the plant is very slightly shaken, the moths very seldom leave the plant, but dart down along the plant, and they are so quick in getting concealed, that they sometimes disappear as if by magic. When disturbed by wind, or rain, or storm, the moths do not fly, but cling to the sheath near the water surface or hide between the leaf and the stem. It is only rarely that the moths are to be seen ovipositing in bright daylight. They have not been seen to feed on plants in the daytime.

### 2. Night Habits.

At about 6 o'clock in the afternoon, when the heat of the day has passed, the period of activity for the moths begins, and continues until well into the night, sometimes until the next morning. Between



eight and nine o'clock the moths are as a rule most active, and at this time, the females are fertilised by the males. In theory, their attention is given to feeding at first, after which the females begin to alternate this with periods of oviposition. In fact, however, their attention is given chiefly to oviposition. The fertilised females remain on the under surface of the leaf, at about two or three inches below the tip, and begin depositing the eggs. As a general rule they do not deposit more than an egg-cluster in a night, and within the following four or five nights their oviposition is entirely finished. The remainder of the night the moths are probably alternately feeding and resting. Early in the evening, when the moths are first on the wing their flight is very swift, but it gradually slows down. As a rule, they are quicker and shyer on clear evenings following hot, dry days, and less active in cloudy or rainy weather.

A single female carries about 120 to 150 eggs in the ovaries. In nearly all females at death there are in the egg-tubules of the ovaries a very small number of fully formed eggs. The percentage of eggs remaining in the ovaries at death varies from 1.6 to about 10. Besides this, there are, very rarely, in the ovaries, a few much smaller eggs, in which the yolk has not yet been formed.

### 3. Attraction by Light.

From old times it has been well known that the moths are adundantly captured by means of trap-lanterns. Until the present time the custom of attracting by lights was made use of for the control of "Itten-O-Meiga", and very rarely, trap-lanterns are still employed. Although the moths are abundantly attracted by light it is still unknown what percentage of the moths emerging naturally are attracted. According to many observations it is probably a large number, and the moths are attracted by light mostly before their oviposition period. The moths are attracted from about five miles distant and also from about a height of 500 feet (see Chapter VIII, IV, G.). It is evident that the moths (famale and male), are

attracted much more by light than by anything else.

### 4. Attraction by Poisoned Sweets.

Although the uselessness of trying to capture the moths by means of trap-sweets has been pointed out again and again, the method was tested very thoroughly, during six years. But all attempts to trap the moths in this way have yielded absolutely negative results. Quite a number of observations were made with different combinations in varying propotions, of cane sugar molasses, beer, vinegar, and raw sugar; some of them poisoned with potassium cyanide or cobalt, and others not. The mixtures were placed in flat pials elevated on pedestals from the water level to six inches high. None of them attracted more than an occasional stray moth, although they were placed in the paddy field where the moths were extremely abundant.

Observations were also made by trap-bands painted with the different mixtures mentioned above and spraying the paddy plants with a mixture of beer, raw sugar and cobalt. In these observations the trap-bands and the sprayed fields were examined especially carefully from eight to eleven o'clock, but no moths could be seen feeding, nor could dead be discovered in the vicinity.

From these tests it is safe to conclude that the moths are not attracted by the sweets.

## F. Effects of External Conditions on Emergence.

Abundance or slightness of the emergences has, of course, some relation to the external conditions; this has been already referred to under the discussion of the larva and pupa.

In Japan, it is noted, by Mr. Nakagawa and Mr. Yano, that the emergence is largely controlled by the atmospheric temperature; but in Formosa this has scarcely ever any effects.

Under normal conditions the moth, on the way to the emergence hole of paddy stem, can satisfactorily emerge, boring through the protecting membranes. Now we must consider the case when the



stalk of rice plant in which the pupa is resting is dried up or buried under the soil or submerged under irrigation water, and the moth on its way to emerge must come out through the soil or water or dried stem. Such different cases always happen at the reaping period or after it, as will now be discussed below.

After the reaping the pupae are found in the stumps or stems, as has been already described. A few series of observations were tried to ascertain whether the moths emerging in the stem were able to get out. In all cases it was found that such moths died in the straw when the stem dried up in the usual way, while others were able to escape, from stems which did not dry up or become folded. Observations were also tried to ascertain if the moths emerging in the stumps were able to came out. The results are given in the table below: –

**Table XXXVIII.** Number of moths which came out of paddy stumps.

| Locality | First series | | Second series | | Third series | | Fourth series | |
|---|---|---|---|---|---|---|---|---|
| | Number of moths which came out of stumps. | Number of moths which died during process of emergence. | Number of moths which came out of stumps. | Number of moths which died during process of emergence. | Number of moths which came out of stumps. | Number of moths which died during process of emergence. | Number of moths which came out of stumps. | Number of moths which died during process of emergence. |
| Taihoku | 0 | 2 | 0 | 0(D) | 0 | 0 | 0 | 0(D) |
| Taichiu | ♀5, ♂2 | 0 | 0 | 0(D) | ♀3, ♂1 | 0(Ds) | 0 | 0(D) |
| Hozan | ♂3 | 6 | 0 | 2 | ♀1 | 1 | 0 | 0(D) |
| Taihoku | ♀3, ♂1 | 1 | 0 | 0(D) | ♀2 | 2 | 0 | 0(D) |
| Taichiu | ♀1, ♂2 | 3 | 0 | 0(D) | ♀4, ♂6 | 0 | 0 | 0(D) |
| Hozan | ♀3 | 2 | 0 | 0(D) | ♀1 | 1 | 0 | 0(D) |

Note :— (D)···All stumps decayed; (Ds)···slightly decayed.
In the observations a paddy field damaged severely by the insects was chosen and divided into four areas.

Each area was six feet square and covered separately with a large breeding cage after the reaping. First series···the stumps were kept in normal condition; Second series···the stumps were submerged; Third series···the stumps were ploughed; Fourth series···the stumps were ploughed and submerged.

Table XXXVIII shows that the moths in process of emerging were not able to come out at all when the stubble was submerged under the water, probably because, in the second and fourth series, the stubble was almost alway rotten and decayed. It also shows that the moths were able to come out when the stubble was kept in a normal condition, or not overturned perfectly. It has often been observed that the moths are very weak and have great trouble in loosening the wall of earth which covers the stubble, to escape out of the stem, although they can emerge in the overturned stumps, on account of the ploughing. The percentage of moths escaping from the place where they first emerge is still unknown, but it is probably not much more than that of those which do not escape.

The effect of rain and wind will be discussed below.

The moths, when they have escaped from the stubble, are sometimes destroyed by the wind and rain, but before they escape from the stubble these seldom disturb them, and they generally come satisfactorily out of the stubble. In the former case, the moths as a rule, cannot deposit their eggs, and very often they deposit unfertilised eggs. After a storm many dead moths are found in the fields; the ovaries of such dead moths contain numerous eggs.

In short, it is safe to conclude that the effect of external conditions on the moths of "Itten-O-Meiga" is much less than on the larva and pupa.

### G. How Far can the Moth fly?

With regard to this problem several suppositions were made by

entomologists, but no experiments have been made by them. The determination of the distance they can fly must be very important for the control of "Itten-O-Meiga". In the year 1910 observations were made to ascertain the probable distance which they can cover from one field to another. In the observation, uncultivated pebbly land was chosen in the district of Ako(Formosa); there were no rice plants, and no other plants, except two species of wild gramineous plants, growing here and there. Before the observation, fifty stools of each plant, injured by certain insects, were examined to ascertain whether the larvae or pupae of "Itten-O-Meiga" were living in them, but no pupae or larvae were found. This land adjointed rice field on the South-west and North-west; and was bounded on the South-east and North-east by mountains where no cultivated plants grew, and its area was somewhat square, and over seven miles in the shortest diameter. The four trap-lanterns, which were constructed like the one shown on Plate XXII, figure I. were exactly similar to a model described by Dr. G. Kojima, Government Entomologist, at Kumamoto(Japan), and were placed on the land along an imaginary diagonal line between West and East, 1800 feet distant from each other. The first night, 26th. May, the first trap-lantern was put in a position where it was one and one third miles away from the nearest rice field. Every night these traps were replaced along the diagonal line, nearer and nearer to the mountains and further away from the rice fields. The lanterns were lighted at about 5 o'clock in the evening, and were kept visible until the next morning. The lights were recognisable by the naked eyes from the rice field, and these traps were examined at about nine o'clock in the morning. The following table summarizes the results:—

**Table XXXIX.** Distance which the moth attracted by light, Sekkoken, Ako (Formosa), 1910.



| Position of the trap. (Distance from rice field.) | Number of moths which trapped by trap-lanterns. | | | Weather. | Date of observation. | Records. |
|---|---|---|---|---|---|---|
| | Female | Male | Total | | | |
| ft. | | | | | | |
| 7200 | 252 | 192 | 444 | Brilliant and calm night. | 27th. May. | All the moths were dead. |
| 9000 | 197 | 289 | 486 | do. | do. | do. |
| 10800 | 155 | 162 | 317 | do. | do. | All the moths were dead, but about a hundred not penetrated with oil. |
| 12600 | 167 | 150 | 317 | do. | do. | All the moths were dead, but hardly any were not penetrated with oil |
| 14400 | 75 | 65 | 140 | do. | 28th. May. | do. |
| 16200 | 35 | 16 | 51 | do. | do. | do. |
| 18000 | 31 | 32 | 63 | do. | do. | do. |
| 19800 | 209 | 132 | 341 | Calm and dark night. | 29th. May. | The moths were mostly dead, but hardly any were not penetrated with oil and a few moths still alive. |
| 21600 | 111 | 160 | 271 | do. | do. | do. |
| 23400 | 256 | 313 | 569 | do. | do. | The moths were almost all alive. |
| 25200 | 0 | 0 | 0 | do. | 30th. May. | .... |
| 27000 | 0 | 1 | 1 | do. | 31th. May. | Practically all the moths were alive. |
| 28800 | 0 | 0 | 0 | do. | do. | .... |

This table shows that the moths were not able to be attracted over 5.45 miles, by means of light; and that in the trap-lantern put at 3.75 miles away from the rice field, still living moths were found, and the proportion of the living moths increased according as the distance away was greater, this being due no doubt, to the fact that the moths were trapped at a later time, having spent many hours in reaching the lantern. In this observation, the lanterns were gradually put further from the rice field, night after night. We can rightly infer that the moths probably were not able to travel directly such a long distance.

A second observation, for the same purpose, was made in the year 1913, on the same land where upland rice and sugar canes were

grown, here and there, in a very small area. These plants and the wild plants grown on the land were examined as in the previous one, but no larvae or pupae of "Itten-O-Meiga" were found. On this land a trap-lantern was put at a certain point about 5 miles distant from the nearest paddy field. The results are given below :—

**Table XL.** Number of the moths attracted by light from a distance of five miles, at Sekkoken, Ako(Formosa), 1913.

| Date. | Number of moths trapped. | | | Weather. | Records. |
|---|---|---|---|---|---|
| | Female | Male | Total | | |
| 31th. October. | 1 | 0 | 1 | Cloudy and breezy night. | The moth was still alive. |
| 1st. November. | 0 | 0 | 0 | Cloudy and somewhat strong windy night. | .... |
| 2nd. November. | 4 | 0 | 4 | Dark and breezy night. | All the moths were still alive. |
| 3rd. November. | 2 | 1 | 3 | do. | do. |
| 4th. November. | 0 | 0 | 0 | do. | .... |
| 5th. November. | 1 | 0 | 1 | do. | The moth was still alive. |
| Total | 8 | 1 | 9 | .... | .... |

This table shows that the moths of "Itten-O-Meiga" can travel a distance of about five miles. According to Dr. G. Kojima it is known that the moth can fly about five miles across the sea in Japan. He also noticed that there were many ships in the sea.

From these observations it is safe to say that the moth of "Itten-O-Meiga" can travel about 5 miles.

## H. Natural Enemies.

Neither in the field nor in the laboratory are any parasitic enemies of "Itten-O-Meiga" found, but the predaceous ones have been noticed by several students in the fields.

Foremost among the predaceous enemies are several species of



robber flies (*Asilidae*) which are often found in the fields. These flies confine their attacks solely to the moths. The only species actually seen with a moth was the large yellowish brown *Ommatius fulvidus* Wied., but judging from their observed habits the other species must undoubtedly catch the moths also. On several occasions flies of the *Ommatius* were brought into the laboratory and tested as to their feeding habits. The moths of "Itten-O-Meiga" were introduced into the breeding cages with the flies, and although the former were concealing themselves under the leaves, three to ten minutes had scarcely elapsed before they had found the moths and, securing them firmly between the legs, were inserting the sword-like proboscis into the moths' body.

Forming another group of predaceous enemies are a few species of *Vespidae*, which are rare in the fields. These Hymenoptera very rarely destroy the moths, but almost always confine their attacks to the larvae of certain Lepidoptera. The only two species actually seen with the moths were *Icaria* sp. and *Polistes hebraeus* Fab. On several occasions these insects were found to have captured the moths and carried them away.

Another enemy of some interest, although probably of very small importance, is the wasp *Ammophila atripes* Smith. On one occasion a nest of this species was found between the leaves and stalk of the rice plant at Koshun (Formosa). The nest is constructed of mud and stored with caterpillars, and one female of "Itten-O-Meiga" was found, of which the wings only remained. This proves that this *Sphegid* sometimes destroys the moths.

Lastly, quite a number of Odonata were observed at various times destroying the moths of "Itten-O-Meiga". The following is a list of the more common dragon-flies which were observed in the paddy fields :—

*Pantala flavescens* Fab.
*Rhyothemis splendens* Ramb.
*Aeschna panorpoides* Ramb.
*Trithemis trivialis* Ramb.
*Lepthemis sabina* Drury.
*Orthetrum albistyla* Selys.
*Agrion* spp.

These dragon flies almost always destroy the moths between five and six o'clock in the evening, but some of them attack the larvae removing from one paddy stem to other, and newly hatched larvae. The Odnata, in general, are the most powerful enemies of the moths of "Itten-O-Meiga".

Among other enemies are bats, spiders and frogs, which in fact, destroy a fair number of the moths. The first two are very powerful enemies, not inferior to dragon flies.

Among the birds there is only one species which probably destroys a small number of the moths. The black Dicrurid, *Buchanga atra* known to have a fondness for moths, is not infrequent in rice fields, and is probably of some service.

It is very often found that the moths die by some unknown cause. Probably there is some disease which attacks them, but is still unknown.

## V. LIFE CYCLE AND GENERATIONS.

The duration of the embryonic, larval, pupal, and imago stages has already been discussed, and the length of the life cycle is easily ascertained by combining these records, made on the same individuals. This has been done in Table XLI, which gives the duration of a series of life cycles during the different parts of the season of 1911, in different localities in Formosa.



**Table XLI.** Length of life cycle, 1911.

| Locality | Eggs laid. | Eggs hatched. | Larvae pupated. | Moths emerged. | Life cycle. |
|---|---|---|---|---|---|
| | | | | | days. |
| Taihoku | 8th. March. | 13th. March. | 11th. May. | 18th. May. | 71 |
| " | 23rd. February. | 2nd. March. | 28th. April. | 6th. May. | 71 |
| Taichiu | 15th. March. | 21st. March. | 11th. May. | 15th. May. | 61 |
| Hozan | 21st. February. | 27th. February. | 20th. April. | 23rd. April. | 61 |
| " | 23rd. April. | 2nd. May. | 6th. June. | 10th. June. | 48 |
| Taihoku | 26th. May. | 30th. May. | 9th. July. | 13th. July. | 48 |
| " | 6th. July. | 11th. July. | 25th. August. | 31st. August. | 56 |
| Taichiu | 16th. July. | 23rd. July. | 25th. August. | 29th. August. | 44 |
| Hozan | 27th. July. | 3rd. August. | 28th. August. | 1st. September. | 36 |
| Taihoku | 6th. September. | 11th. September. | 2nd. April, 1912. | 7th. April, 1912. | 182 |
| Taichiu | 6th. September. | 12th. September. | 21st. February, 1912. | 28th. February, 1912. | 168 |
| Hozan | 7th. September. | 13th. September. | 12th. October. | 20th. October. | 43 |

The influence of the seasonal variation in temperature is plainly to be seen, the length of the life cycle varying from 36 to 182 days in the whole island. It will be noticed, however, that there is hardly ever much difference in each locality during the hottest part of the summer, and that the difference is seen only from September to following April. This is due, no doubt, to the atmospheric temperature in each locality (see Table XLV).

It has long been stated that the number of generations annually of "Itten-O-Meiga" in Japan is three. This, however, cannot be accepted for Formosa. In the determination of the number of generations, field observation are most to be relied upon for the making of trustworthy records; but the results of these are often unsatisfactory, though, theoretically, they will undoubtedly furnish the information desired. Statements based on actual breeding experiments will very often show facts departing from the natural conditions expected.

Now the number of generations annually, of "Itten-O-Meiga" in Formosa, may be determined by means of the following three series of observations :—

| Locality. | Year. | Generation. | Moths emerged. | Eggs deposited. | Eggs hatched. | Larvae pupated. | Length of life cycle. | Notes. |
|---|---|---|---|---|---|---|---|---|
| Taihoku | 1910 | I | 6th. March. | 10th. March. | 24th. March. | 17th. May. | 77 days. | Condnued from the preceding breeding. |
| | | II | 22nd. May. | 26th. May. | 30th. May. | 23rd. June. | 32 " | |
| | | III | 28th. June. | 6th. July. | 11th. July. | 25th. August. | 58 " | |
| | | IV | 31st. August. | 6th. Septemb. | 11th. Septemb. | 21st. February. 1911. | 174 " | |
| | 1911 | I | 27th. February. | 8th. March. | 13th. March. | 11th. May. | 80 days. | Unfortunately the moths emerged from the pupae which were the last brood of the preceding observation could not oviposit. On the 27th. February, the moths were again collected. |
| | | II | 18th. May. | 24th. May. | 29th. May. | 30th. June. | 53 " | |
| | | III | 11th. July. | 27th. July. | 31st. July. | 26th. August. | 49 " | |
| | | IV | 3rd. September. | 11th. September. | 17th. Septemb. | 2nd. April, 1912. | 188 " | |
| Hozan | 1909 | I | 21st. February. | 22nd. February. | 6th. March. | 20th. April. | 64 days. | On the 21st. February the moths attracted by light were collected and the breeding was begun with them. |
| | | II | 25th. April. | 27th. April. | 3rd. May. | 16th. June. | 54 " | |
| | | III | 18th. June. | 20th. June. | 26th. June. | 22nd. July. | 37 " | |
| | | IV | 25th. July. | 27th. July. | 31st. July. | 20th. August. | 32 " | |
| | | V | 26th. August. | 29th. August. | 4th. Septemb. | 3rd. October. | 45 " | |
| | | VI | 10th. October. | 13th. October. | 20th. October. | 25th. January, 1910. | 114 " | |
| | 1910 | I | 1st. February. | 8th. February. | 23rd. February. | 19th. April. | 82 days. | Continued from the preceding breeding. |
| | | II | 24th. April. | 28th. April. | 5th. May. | 6th. June. | 50 " | |
| | | III | 13th. June. | 19th. June. | 25th. July. | 19th. July. | 41 " | |
| | | IV | 24th. July. | 27th. July. | 1st. August. | 26th. August. | 39 " | |
| | | V | 1st. September. | 7th. September. | 13th. Septemb. | 12th. October. | 50 " | |
| | | VI | 20th. October. | 24th. October. | 1st. November. | 28th. January, 1911. | 104 " | |



## A. Actual Breeding Observations.

At the beginning of the year 1909 it was decided to carry a series of consecutive generations through the following three years under natural field conditions, in three different localities. This work was carried on in a large field breeding cage, placed in an experimental field in each locality. The cage consisted of a solid framework six feet cube, covered with an ordinary window screen and provided with a small door in the side (see Plate XVII). In it were planted about 30 to 40 stools of paddy. The screen prevented the escape of any moths or larvae, but left them subjected to very nearly normal weather conditions. It also served to kept out predaceous enemies and many of the larger parasites, thus providing against possible depletion from these sources, and at the same time preventing access to the plants by moths outside of the cage. The paddy plants of the first crop were reaped when they were ripe, much later than the usual time, and the large young plants of the second crop were planted between the stumps.

The cage was stocked with a newly-laid egg-cluster, not parasitised by any insect enemies at the beginning of the early brood season, and the forthcoming generation of "Itten-O-Meiga" was traced in its development. The following table, compiled from daily records, summarizes very briefly the average duration of each generation.

**Table XLII.** Generation in Formosa.

| Locality. | Year. | Generation. | Moths emerged. | Eggs deposited. | Eggs hatched. | Larvae pupated. | Length of life cycle. | Notes. |
|---|---|---|---|---|---|---|---|---|
| Taihoku | 1909 | I | 20th. February. | 23rd. February. | 2nd. March. | 28th. April. | 75 days. | |
| | | II | 6th. May. | 10th. May. | 19th. May. | 21st. June. | 53 " | On the 20th. February, the moths attracted by light were collected for the lots of the observation. |
| | | III | 28th. June. | 29th. June. | 5th. July. | 6th. August. | 46 " | |
| | | IV | 12th. August. | 15th. August. | 21st. August. | 18th. Septemb. | 43 " | The breeding continued satisfactorily until the next year. |
| | | V | 24th. Septemb. | 28th. Septemb. | 5th. October. | 27th. February. 1910. | 163 " | |

| | | | | | |
|---|---|---|---|---|---|
| Tainan 1911 | I | 12th. March. | 15th. March. | 24th. March. | 25th. April. | 48 days. | On the 12th. March, the moths were collected by means of light, and the two egg-clusters laid by them were the first lots. At the beginning of September the breeding cage was broken by a storm, the egg-clusters were unavoidably collected on the 21st. September, and the breeding was once again begun. |
| | II | 29th. April. | 3rd. May. | 10th. May. | 10th. June. | 45 " | |
| | III | 13th. June. | 15th. June. | 21st. June. | 11th. July. | 32 " | |
| | IV | 15th. July. | 18th. July. | 23rd. July. | 25th. August. | .... | |
| | V | .... | 21st. September. | 23rd. Septemb. | 28th. February, 1912. | .... | |

From these actual breedings, it is evident that the number of generations of "Itten-O-Meiga" in Formosa, annually, varies from 4 to 5 in the northern part to six in the southern part, and in mid part it is five.

## B. Probable Generations which suggested from the Maximum Number of the Moths attracted to Trap-lantern.

During four years, 1909-1912, an attempt was made to ascertain, for different localities of the rice belt, the periods of maximum emergence of the moths during the season. It was thought that the records of moths trapped by light would indicate approximately the period of greatest abundance of the moths, thus marking the respective generations.

A common trap-lantern was put in a definite place in the rice field, during the time of the observation, and it was lighted at five o'clock in the evening every day. Every morning the trapped moths were counted, and the records made, as follows:—

**Table XLIII.** Number of the moths which attracted by a trap-lantern, in Formosa.



Number of the moths which trapped, in each month.

| Tainoku | Year | Date. | Jan. ♂ | Jan. ♀ | Feb. ♂ | Feb. ♀ | Mar. ♂ | Mar. ♀ | Apr. ♂ | Apr. ♀ | May. ♂ | May. ♀ | June. ♂ | June. ♀ | July. ♂ | July. ♀ | Aug. ♂ | Aug. ♀ | Sept. ♂ | Sept. ♀ | Oct. ♂ | Oct. ♀ | Nov. ♂ | Nov. ♀ | Dec. ♂ | Dec. ♀ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1909 | 1st. to 5th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 11 | 3 | 0 | 1 | 3 | 8 | 8 | 3 | 3 | 0 | 0 | 0 |
| | | 6th. to 10th. | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 58 | 2 | 1 | 2 | 63 | 94 | 90 | 56 | 1 | 0 | 0 | 0 |
| | | 11th. to 15th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 23 | 1 | 2 | 0 | 150 | 66 | 69 | 41 | 0 | 0 | 0 | 0 |
| | | 16th. to 20th. | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 4 | 8 | 7 | 0 | 4 | 0 | 51 | 40 | 6 | 5 | 0 | 0 | 0 | 0 |
| | | 21th. to 25th. | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 0 | 1 | 1 | 0 | 0 | 3 | 1 | 25 | 1 | 5 | 0 | 0 | 0 | 0 | 0 |
| | | 26th. to the end. | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 1 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Total. | 3 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 15 | 0 | 31 | 19 | 106 | 6 | 12 | 4 | 507 | 285 | 178 | 105 | 4 | 0 | 0 | 0 |
| | 1910 | 1st. to 5th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 | 29 | 3 | 16 | 6 | 11 | 38 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 6th. to 10th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 1 | 44 | 10 | 5 | 2 | 32 | 57 | 6 | 0 | 0 | 0 | 0 | 0 |
| | | 11th. to 15th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 0 | 42 | 8 | 0 | 0 | 17 | 20 | 7 | 0 | 0 | 0 | 0 | 0 |
| | | 16th. to 20th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 18 | 0 | 89 | 2 | 0 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 |
| | | 21st. to 25th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 4 | 9 | 0 | 1 | 5 | 6 | 0 | 0 | 0 | 0 |
| | | 26th. to the end. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 5 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Total. | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 9 | 0 | 39 | 3 | 316 | 25 | 62 | 31 | 178 | 117 | 26 | 6 | 0 | 0 | 0 | 0 |
| | 1911 | 1st. to 5th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 143 | 19 | 0 | 0 | 0 | 0 | 75 | 44 | 0 | 0 | 0 | 0 |
| | | 6th. to 10th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 98 | 20 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 |
| | | 11th. to 15th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 17 | 6 | 16 | 8 | 10 | 8 | 43 | 47 | 0 | 0 | 0 | 0 |
| | | 16th. to 20th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 26 | 5 | 0 | 0 | 71 | 72 | 5 | 24 | 2 | 2 | 0 | 0 | 0 | 0 |
| | | 21st. to 25th. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 54 | 0 | 256 | 120 | 0 | 0 | 84 | 78 | 11 | 18 | 7 | 23 | 0 | 0 | 0 | 0 |
| | | 26th. to the end. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 78 | 0 | 170 | 158 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 7 | 0 | 0 | 0 | 0 |
| | | Total. | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 349 | 0 | 740 | 481 | 329 | 76 | 263 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tatchu | 1910 | 1st. to 5th. | 0 | 0 | 0 | 0 | 4 | 10 | 3 | 19 | 51 | 46 | 11 | 8 | 313 | 273 | 13 | 63 | 1 | 7 | 7 | 23 | 1 | 11 | 0 | 1 |
| | | 6th. to 10th. | 0 | 0 | 0 | 0 | 16 | 36 | 4 | 18 | 42 | 50 | 7 | 49 | 28 | 45 | 3 | 19 | 4 | 19 | 11 | 22 | 4 | 18 | 0 | 3 |
| | | 11th. to 15th. | 1 | 0 | 0 | 0 | 1 | 7 | 5 | 10 | 15 | 43 | 34 | 188 | 100 | 80 | 3 | 8 | 4 | 60 | 2 | 5 | 0 | 4 | 1 | 1 |
| | | 16th. to 20th. | 0 | 0 | 0 | 0 | 4 | 10 | 2 | 12 | 17 | 45 | 16 | 96 | 23 | 66 | 2 | 9 | 0 | 4 | 0 | 4 | 0 | 2 | 0 | 2 |
| | | 21st. to 25th. | 0 | 0 | 0 | 0 | 15 | 32 | 21 | 58 | 2 | 4 | 19 | 59 | 3 | 11 | 0 | 4 | 8 | 6 | 2 | 5 | 0 | 8 | 0 | 2 |
| | | 26th to the end. | 1 | 0 | 4 | 0 | 10 | 22 | 16 | 34 | 12 | 2 | 393 | 369 | 17 | 23 | 0 | 3 | 33 | 33 | 4 | 12 | 3 | 7 | 0 | 3 |
| | | Total. | 2 | | 4 | | 167 | | 202 | | 329 | | 1249 | | 982 | | 127 | | 179 | | 97 | | 57 | | 13 | |
| | 1911 | 1st. to 5th. | 10 | 0 | 3 | 0 | 14 | 2 | 12 | 2 | 29 | 68 | 16 | 14 | 157 | 703 | 41 | 11 | 7 | 5 | 27 | 13 | 20 | 5 | 11 | 3 |
| | | 6th. to 10th. | 4 | 0 | 6 | 0 | 25 | 4 | 11 | 3 | 31 | 22 | 15 | 4 | 74 | 107 | 17 | 4 | 5 | 4 | 25 | 8 | 14 | 4 | 11 | 3 |
| | | 11th. to 15th. | 1 | 0 | 16 | 5 | 4 | 1 | 6 | 1 | 9 | 2 | 13 | 3 | 23 | 22 | 27 | 10 | 18 | 6 | 22 | 1 | 15 | 4 | 3 | 0 |
| | | 16th. to 20th. | 5 | 0 | 9 | 2 | 5 | 1 | 13 | 2 | 85 | 415 | 493 | 385 | 41 | 47 | 43 | 24 | 69 | 28 | 25 | 8 | 27 | 8 | 13 | 1 |
| | | 21st. to 25th. | 11 | 3 | 13 | 3 | 19 | 6 | 11 | 3 | 69 | 420 | 464 | 1007 | 43 | 25 | 82 | 18 | 91 | 26 | 31 | 10 | 22 | 7 | 7 | 2 |
| | | 26th. to the end. | 1 | 0 | 20 | 4 | 20 | 6 | 16 | 1 | 33 | 102 | 778 | 1412 | 115 | 45 | 15 | 6 | 79 | 29 | 82 | 17 | 8 | 0 | 9 | 2 |
| | | Total. | 35 | | 81 | | 107 | | 81 | | 1285 | | 4604 | | 1402 | | 298 | | 367 | | 269 | | 134 | | 64 | |
| | 1912 | 1st. to 5th. | 1 | 0 | 5 | 1 | 1 | 0 | 2 | 0 | 4 | 0 | 4 | 3 | 11 | 32 | 12 | 2 | 0 | 2 | 2 | 2 | 14 | 6 | 4 | 0 |
| | | 6th. to 10th. | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 5 | 2 | 12 | 3 | 12 | 98 | 9 | 4 | 2 | 4 | 2 | 5 | 20 | 5 | 7 | 2 |
| | | 11th. to 15th. | 3 | 0 | 3 | 1 | 1 | 0 | 1 | 0 | 37 | 89 | 43 | 57 | 10 | 48 | 16 | 4 | 1 | 0 | 10 | 5 | 6 | 1 | 17 | 6 |
| | | 16th. to 20th. | 5 | 1 | 2 | 0 | 2 | 0 | 1 | 0 | 5 | 19 | 2 | 11 | 27 | 60 | 23 | 5 | 0 | 0 | 6 | 4 | 7 | 3 | 4 | 0 |
| | | 21st. to 25th. | 0 | 0 | 2 | 0 | 2 | 0 | 4 | 1 | 13 | 11 | 37 | 50 | 17 | 51 | 1 | 0 | 1 | 0 | 2 | 1 | 5 | 1 | 2 | 0 |
| | | 26th. to the end. | 2 | 0 | 0 | 0 | 1 | 0 | 5 | 2 | 9 | 1 | 13 | 41 | 8 | 5 | 0 | 0 | 2 | 1 | 9 | 2 | 8 | 2 | 3 | 1 |
| | | Total. | 14 | | 15 | | 8 | | 16 | | 195 | | 276 | | 379 | | 74 | | 17 | | 50 | | 78 | | 46 | |



| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hozan | 1910 | 1st. to 5th. | 0 | 0 | 1 | 2 | 0 | 0 | 4 | 9 | 34 | 70 | 18 | 107 | 0 | 0 | 8 | 15 | 71 | 11 | 88 | 160 | 1 | 2 | 0 | 0 |
| | | 6th. to 10th. | 0 | 0 | 0 | 0 | 3 | 5 | 2 | 5 | 40 | 62 | 12 | 123 | 0 | 0 | 3 | 13 | 51 | 34 | 68 | 293 | 11 | 5 | 0 | 0 |
| | | 11th. to 15th. | 0 | 0 | 0 | 0 | 8 | 4 | 6 | 14 | 31 | 30 | 6 | 19 | 2 | 4 | 4 | 17 | 9 | 16 | 9 | 2 | 0 | 1 | 0 | 0 |
| | | 16th. to 20th. | 0 | 0 | 0 | 0 | 3 | 0 | 23 | 48 | 3 | 1 | 2 | 5 | 12 | 27 | 11 | 13 | 0 | 7 | 6 | 0 | 0 | 0 | 0 | 0 |
| | | 21st. to 25th. | 0 | 0 | 0 | 0 | 39 | 46 | 84 | 114 | ? | ? | 0 | 0 | 27 | 36 | 4 | 9 | 23 | 174 | 2 | 1 | 0 | 0 | 0 | 0 |
| | | 26th. to the end. | 9 | 7 | 0 | | 36 | 22 | 62 | 102 | 22 | 57 | 0 | 0 | 68 | 109 | 3 | 3 | 70 | 226 | 10 | 2 | 0 | 0 | 0 | 0 |
| | | Total. | 16 | | 3 | | 166 | | 480 | | 350 | | 292 | | 285 | | 103 | | 632 | | 641 | | 20 | | 0 | |
| | 1911 | 1st. to 5th. | 0 | 0 | 0 | 0 | 2 | 9 | 0 | 0 | 138 | 202 | 9 | 10 | 46 | 77 | 4 | 2 | 0 | 0 | 0 | 4 | 0 | 1 | 0 | 0 |
| | | 6th. to 10th. | 2 | 3 | 0 | 1 | 0 | 2 | 7 | 104 | 144 | 206 | 4 | 6 | 17 | 35 | 3 | 0 | 0 | 0 | 6 | 12 | 0 | 0 | 0 | 0 |
| | | 11th. to 15th. | 2 | 6 | 10 | 42 | 9 | 34 | 4 | 108 | 24 | 50 | 37 | 77 | 5 | 13 | 0 | 0 | 0 | 0 | 5 | 2 | 9 | 1 | 2 | 0 |
| | | 16th. to 20th. | 4 | 8 | 0 | 0 | 0 | 0 | 19 | 64 | 2 | 17 | 33 | 90 | 22 | 24 | 0 | 0 | 30 | 254 | 2 | 3 | 0 | 0 | 1 | 3 |
| | | 21st. to 25th. | 5 | 34 | 6 | 16 | 0 | 11 | 12 | 10 | 96 | 126 | 24 | 37 | 47 | 37 | 0 | 0 | 20 | 191 | 3 | 2 | 0 | 0 | 1 | 0 |
| | | 26th. to the end. | 0 | 3 | 21 | 26 | 0 | 0 | 0 | 0 | 57 | 63 | 107 | 164 | 4 | 19 | 0 | 0 | 44 | 110 | 7 | 3 | 0 | 0 | 1 | 1 |
| | | Total. | 62 | | 120 | | 67 | | 328 | | 1125 | | 598 | | 348 | | 9 | | 649 | | 49 | | 11 | | 9 | |
| | 1912 | 1st. to 10th. | 5 | 6 | 13 | 18 | 13 | 14 | 12 | 8 | 0 | 0 | 12 | 2 | 0 | 0 | 0 | 0 | 3 | 11 | 26 | 76 | 0 | 5 | 0 | 0 |
| | | 11th. to 20th. | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 2 | 6 | 0 | 0 | 4 | 3 | 2 | 1 | 12 | 39 | 88 | 0 | 7 | 0 | 1 |
| | | 21st. to the end. | 3 | 0 | 0 | 0 | 5 | 16 | 0 | 6 | 56 | 23 | 0 | 0 | 0 | 5 | 0 | 12 | 3 | 18 | 5 | 22 | 1 | 3 | 7 | 1 |
| | | Total. | 19 | | 31 | | 48 | | 26 | | 102 | | 20 | | 9 | | 17 | | 48 | | 256 | | 16 | | 9 | |

From these records it will be seen that the moths emerge almost throughout the year, excepting in the northern part. It is, however, evident that the emergence decreased greatly at certain parts of the different months, or throughout a month. Supposing the periods of these decreases to represent the time of the change of generations, it may be concluded that broods of "Itten-O-Meiga" emerge four or five times in the northern part, five times in the mid part, and six times in the southern part.

## C. Field Observations.

The attempt to ascertain the number of generations annually by the results of field observations, is sometimes very unsatisfactory. However, if the observations are made throughly, the number of the generations, based on such records, should be much more accurate and practically correct, than those based on the records of breeding observations.

In different localities, the natural conditions of "Itten-O-Meiga" were studied, throughout the whole year, in one particular locality. The following table, compiled from daily records, summarizes very briefly the conditions of "Itten-O-Meiga" in different months: —

**Table XLIV.** The conditions of "Itten-O-Meiga" which observed in the rice field, Formosa.

| Year. | Month. | Records. | | |
|---|---|---|---|---|
| | | Taihoku. | Taichiu. | Hozan. |
| 1910 | January. | Larval stage. | Mostly larval stage; very rarely pupae were found. | Mostly larval stage; rarely pupae were found. |
| | February. | Mostly larval stage; rarely pupae were found and very rarely pupa-cases were found. | In the first 20 days, larvae and pupae were found; at the end of the month egg-clusters were found. | Mostly larval stage; in the last ten days, pupae and pupa-cases were found. |



| Year. | Month. | Records. | | |
|---|---|---|---|---|
| | | Taihoku. | Taichiu. | Hozan. |
| 1910 | March. | Pupa-cases were abundantly found, in the second 15 days egg-clusters and newly hatched larvae were found. | All stages were found; at the end of the month newly hatched larvae were abundantly found. | In the first ten days pupae were found; in the last 20 days pupa-cases, egg-clusters and newly hatched larvae were found. |
| | April. | Mostly larval stage. | Mostly larval stage, very often pupae were found. | In the first 20 days mostly larval stage; pupae and pupa-cases were found near the end of the month. |
| | May. | Old larvae, pupae and pupa-cases were found; in the last 10 days egg-clusters were found. | Old larvae, pupae and pupa-cases were found; in the last ten days egg-clusters were abundantly found. | In the first ten days newly hatched larvae were found; Mostly larval stage. |
| | June. | In the first ten days newly hatched larvae were abundantly found; in the last ten days pupa and pupa-cases were found. | In the first ten days newly hatched larvae were abundantly found; in the last ten days pupae and pupa-cases were found. | In the first ten days pupa-cases and egg-clusters were found; in the last 20 days larvae were chiefly found. |
| | July. | In the first ten days egg-clusters and newly hatched larvae were found; in the last ten days pupae and very rarely pupa-cases were found. | Mostly larval stage; in the first ten days egg-clusters were abundantly found. | Mostly matured larval stage; in the last ten days pupae, pupa-cases and egg-clusters were found. |
| | August. | do. | Mostly larval stage. | Mostly larval stage; in the first ten days egg-clusters were found. |
| | September. | In the first ten days pupa-cases were abundantly found; in the last 20 days egg-clusters and very rarely newly hatched larvae were found. | In the first 15 days larvae were chiefly found; in the last 15 days pupae, pupa-cases and egg-clusters were found. | In the first ten days pupae and pupa-cases were found; in the last 20 days egg-clusters and newly hatched larvae were found. |
| | October. | Egg-clusters and newly hatched larvae were chiefly found. | Egg-clusters and newly hatched larvae were chiefly found. | Mostly larval stage; in the last ten days pupae were found. |
| | November. | Larval stage. | Larval stage. | In the first ten days pupa-cases and egg-clusters were chiefly found; in the last 20 days larvae were abundantly found. |
| | December. | Larval stage. | Larval stage. | Larval stage. |

| | | | |
|---|---|---|---|
| January. | Larval stage. | Mostly larval stage, a few pupae were found. | In the first ten days larvae, pupae, pupa-cases and very rarely egg-clusters were found; in the last 20 days pupae, pupa-cases, egg-clusters and newly hatched larvae were found. |
| February. | In the first ten days larvae were found; in the last 20 days matured larvae, pupae and pupa-cases were found; in the last 10 days egg-clusters were abundantly found. | In the first 20 days matured larvae and pupae were chiefly found; in the last ten days pupa-cases and egg-clusters were found. | In the first ten days larvae were chiefly found; in the last 20 days larvae, pupae and pupa-cases were found. |
| March. | Matured larvae, pupae pupa-cases and egg-clusters were found; in the last 20 days newly hatched larvae were found. | Pupa-cases, egg-clusters and newly hatched larvae were found. | In the first ten days egg-clusters were found; mostly larval stage. |
| April. | Mostly larval stage; in the last ten days pupae were found. | Mostly larval stage; in the last ten days pupae were found. | In the first ten days pupae were found; in the last 20 days pupa-cases, egg-clusters and newly hatched larvae were found. |
| May. | In the first 20 days matured larvae, pupae and pupa-cases were found; in the last ten days egg-clusters and newly hatched larvae were found. | Pupa-cases, egg-clusters and newly hatched larvae were found. | Egg-clusters and larvae were found. |
| June. | In the first ten days larvae and pupae were found; in the last 20 days pupae, pupa-cases, egg-clusters and matured larvae were found. | In the first ten days larvae were found; in the second ten days larvae and pupae were found; in the last ten days all stages were found. | In the first 20 days larvae and pupae were chiefly found; in the last ten days pupa-cases and egg-clusters were found. |
| July. | In the first ten days matured larvae, pupae, pupa-cases and egg-clusters were found; in the last 20 days pupa-cases, egg-clusters and newly hatched larvae were found. | In the first 20 days egg-clusters and larvae were found; in the last ten days pupa-cases and egg-clusters were found. | In the first ten days pupa-cases, egg-clusters and newly hatched larvae found; in the second ten days larvae and pupae were found; in the last ten days pupa-cases and very rarely egg-clusters were found. |
| August. | In the first ten days larvae were found; in the second ten days matured larvae and pupae were found; in the last ten days matured larvae, pupae, pupa-cases and egg-clusters were found. | In the first ten days larvae were found; in the second ten days matured larvae and pupae were found; in the last ten days matured larvae, pupae, pupa-cases and egg-clusters were found. | Mostly larval stage; in the last ten days pupae were found. |





| | | | |
|---|---|---|---|
| September. | In the first 20 days matured larvae, pupae, pupa-cases and egg-clusters were found; in the last ten days egg-clusters and young larvae were found. | In the first 20 days matured larvae, pupae, pupa-cases and egg-clusters were found; in the last ten days egg-clusters and young larvae were found. | In the first ten days pupae, pupa-cases and egg-clusters were found; in the second ten days pupa-cases, egg-clusters and newly hatched larvae were found; in the last ten days young larvae were chiefly found. |
| October. | In the first ten days pupa-cases, egg-clusters and newly hatched larvae were found; in the second ten days egg-clusters and newly hatched larvae were found; in the last ten days young larvae were chiefly found. | In the first ten days egg-clusters and newly hatched larvae were found; in the last 20 days young larvae were chiefly found. | In the first ten days matured larvae were chiefly found; in the second ten days pupa-cases and egg-clusters were found; in the last ten days young larvae were chiefly found. |
| Nov. | Larval stage. | Larval stage. | Larval stage. |
| Dec. | Larval stage. | Larval stage. | Mostly larval stage; in the last ten days pupae were rarely found. |

This table shows that, in the northern part, the moths of the first generation emerge until March, those of the second until May, those of the third until July, and those of the fourth until October; that in the mid part, the moths of the first generation emerge until March, of the second until May, of the third until June, of the fourth until July, and of the fifth until September, excepting for those of the third and fourth, which, in the year 1910, emerged respectively until July and September. In the southern part, the moths of the first generation emerge until February, those of the second until April, those of the third until June, those of the fourth until July, those of the fifth until September, and those of the sixth until November; but in the year 1909, the first moths emerged until March.

From the above three different observations, it is safe to conclude that the number of generations, annually, of "Itten-O-Meiga" in Formosa, varies from four or five in the north, to five or six in the south; and that it is five, or even four, in the mid part.

The influence of atmospheric temperatures on the number of annual generations is exceedingly interesting. In the different localities, it is almost always the same from May until September; "Itten-O-Meiga" has three generations in this season; and from October until the following March it varies from one to three. This is evident from a comparison between the number of generations and the atmospheric temperature, which is given in Table XLV.

**Table XLV.** Monthly mean of atmospheric temperature of Formosa, in the last ten years.

| Month. | Locality. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Taihoku. | | | Taichiu. | | | Tainan (near Horan). | | |
| | Mean. | Maximum. (mean). | Minimum. (mean). | Mean. | Maximum. (mean). | Minimum. (mean). | Mean. | Maximum. (mean). | Minimum. (mean). |
| | °C. | °C. | °C. | °C. | °C. | °C. | °C. | °C. | °C. |
| January. | 15.6 | 19.3 | 12.9 | 16.1 | 21.6 | 12.3 | 17.4 | 23.9 | 13.3 |
| February. | 13.9 | 17.4 | 11.2 | 14.7 | 19.1 | 11.1 | 16.2 | 22.9 | 12.0 |
| March. | 17.1 | 20.8 | 14.3 | 18.3 | 23.2 | 15.0 | 19.8 | 26.0 | 15.0 |
| April. | 20.8 | 24.8 | 17.6 | 22.1 | 26.7 | 18.7 | 23.5 | 29.1 | 19.3 |
| May | 24.3 | 28.8 | 20.8 | 25.2 | 29.6 | 21.7 | 26.2 | 31.1 | 22.4 |
| June. | 26.3 | 30.8 | 22.8 | 25.6 | 30.6 | 23.2 | 27.0 | 31.2 | 23.8 |
| July. | 27.8 | 32.6 | 24.0 | 27.4 | 31.6 | 23.9 | 27.7 | 32.1 | 24.4 |
| August. | 27.6 | 32.1 | 24.1 | 27.1 | 31.3 | 23.8 | 27.4 | 31.7 | 24.2 |
| September. | 29.9 | 30.5 | 22.5 | 26.2 | 31.0 | 22.6 | 27.0 | 32.3 | 23.3 |
| October. | 22.9 | 26.9 | 19.9 | 23.5 | 29.0 | 19.9 | 24.7 | 30.5 | 20.7 |
| November. | 19.5 | 22.8 | 17.0 | 20.1 | 25.6 | 16.2 | 21.3 | 27.4 | 17.2 |
| December. | 16.7 | 20.5 | 13.8 | 17.0 | 22.8 | 12.8 | 18.3 | 24.8 | 14.1 |
| Average. | 21.5 | 25.6 | 18.4 | 22.0 | 26.9 | 18.4 | 23.0 | 28.6 | 19.2 |

In Japan, it has long been stated that the number of generations annually is three. It does not appear, however, that this statement is based on actual breeding observations, but rather on the result of field observations. Recently it has been ascertained by several entomologists, that it varies from two, in the cold locality of the occurrence of "Itten-O-Meiga", to three in most parts. This is



based chiefly on the results of actual breeding, as shown below:—

**Table XLVI.** Generations of "Itten-O-Meiga", in Japan.

| Locality. | Generation. | Eggs deposited. | Larvae hatched. | Larvae pupated. | Moths emerged. | Duration of life cycle. |
|---|---|---|---|---|---|---|
| Yehime. | I. | 22. May to 15. June. | 2. June to 25. June. | 15. July to 1. August. | 19. July to 1. August. | 61–52 days |
| | II. | 21. July to 5. August. | 28. July to 12. August. | 19. August to 12. Septemb. | 19. August to 12. Septemb. | 31–43 " |
| | III. | 21. August to 19. Septemb. | 28. August to 27. Septemb. | 28. April to 21. May. | 19. May to 10. June. | 251–252 " |
| | Duration of each stage. | Egg stage. 7-21 days. | Larval stage. 22-253 days. | Pupal stage. 4–21 days. | Imago stage. 2-5 days. | |
| Kagawa. | I. | 1–10. June. | 10 20. June. | 10-20. July. | 20–31. July. | about 60 days |
| | II. | 1–10. August. | 1–31. August. | 1–31. May. | 20. May to 10. June. | about 300 " |
| Fukuoka. | I. | 7. June. | 21. June. | 8. July. | 18. July. | 42 days |
| | II. | 19. July. | 25. July. | 11. August. | 22. August. | 34 " |
| | III. | 13. August. | 25. August. | 27. April. | 8. May. | 279 " |
| | Duration of each stage. | Egg stage. 7-15 days. | Larval stage. 18-246 days. | Pupal stage. 11–12 days. | Imago stage. 2–7 days. | |

According to the above table it will be noticed that the duration of the life cycle in the growing season of the rice plants is generally the same as it is in Formosa, and from the Autumn to the next Spring it differs. This is probably due chiefly to the differences of atmospheric temperatures.

In conclusion, the duration of the life cycle of "Itten-O-Meiga" during the Summer, does not, apparently, increase or decrease according as the latitude differs. Upon the assumption of the facts known in Java, this is probably also the case in all other countries. The number of generations varies from two in the northern limit of the distribution, to six, or probably more than six, in tropical countries, where it has not been studied.

## CHAPTER IX.

### Increase In Numbers During The Season.

The comparative difference in numbers between the moths of the different generations can be ascertained in a general way from Table XLIII. It is seen that the moth occurs in greater numbers at the reaping period of the first crop than at the beginning of its cultivation, and that, in the generation just after the reaping, it occurs apparently in fewer numbers than in the preceding generation, and the number of the moths in the last generation is more than in the preceding one.

A single female moth, in the early period, lays probably about 120 eggs. The number of eggs laid by a single female does not vary in the different broods. Observations show that about five in ten of these eggs, or sixty, will give rise to destructive larvae. Allowing for the probable decimation of twenty per cent, by the parasites and predaceous enemies of the growing larvae, there remain some forty-eight larvae of the first generation to mature and to pupate. The forty-eight pupae will probably be diminished to forty-five, by several natural enemies, or from these forty-five moths will emerge. Half of these, emerging as female moths of the second generation, will lay in all some 5400 eggs. According to the same calculations the number of the third generation of moths will be 2052, and the number of the larvae will be 61560, or there will still remain some 49248 larvae of the third generation to mature on ripening rice plants of the first crop, for every moth which emerged the previous Spring.

This shows the great importance of destroying the larvae of the first generation, as every one of them will have about 820 descendants in June and July, capable of completely ruining 110 paddy stools; namely, the descendants of a single larva of the first generation hatched from the egg, laid in the rice field (not the rice bed), will destroy entirely about 2.5 pounds of unhulled rice.



At the beginning of the second crop, about 820 females will have emerged from 49248 larvae at the end of the third generation, supposing that about two thirds of the third generation of larvae are buried under the soil or water, by reason of the reaping of the first crops. Probably some 19680 larvae will appear to mature and to pupate in the fourth generation, and abont 448704 in the fifth generation, having a capability of completely ruining about 39360 stems (or about 2624 stools) in the northern part of the island and about 897408 stems (or about 59827 stools) in the mid or southern part.

In short, a couple egg laid in the rice field will probably cause the loss of about six pounds of unhulled rice, in the northern part, and about 140 pounds in the other parts, throughout the year in Formosa.

## CHAPTER X.

### Insects Very Often Mistaken For This Insect.

There are two other borers which injure rice plants in practically exactly the same manner as "Itten-O-Meiga", so that, unless the insects themselves are in evidence, it is not possible to tell their work from that of "Itten-O-Meiga". Unfortunately, both of them are very often present in some districts in large numbers, in a small area, and damage which they cause is material compared to that done by "Itten-O-Meiga" in such a district.

It is rather usual for farmers to confuse it with the two other species, and students very often make the same mistake. The first is *Chilo simplex* Butl., which usually feeds on rice plant, sugar cane, upland rice, *Zizania latifolia* Turcz., wheat, barley, etc. It bores into the paddy stem in exactly the same way as "Itten-O-Meiga", but it does not bore to the lower part of the stalk, and two or three larvae can live in a single stem. In Formosa, the emergence of the

rarely in the stem, but not covered with thick pupal cocoon.

a. Wings reaching to the apical margin of the fourth abdominal segment; the apex of the abdomen with a few short processes..... .. *Chilo simplex.*

b. Wings extending to the fifth abdominal segment and broad; the apex of the abdomen with three spines.....*Nonagria inferens.*

2. Found usually in the stem, very rarely between the stem and the sheath, but covered with a thick pupal cocoon.....*Schoen. incertellus.*

Larval habits:— 1. Living gregariously immediately after hatching.

a. Almost always in the stem···*Chilo simplex.*

b. Not always in the stem and injuring irregularly, either from the outside or inside of the stem .....*Nonagria inferens.*

2. Living entirely separately immediately after hatching, and almost always in the stem, injuring rather regularly.....*Schoen. incertellus.*

## CHAPTER XI.

### Methods of Control.

### I. HISTORY OF THE DIFFERENT METHODS OF CONTROL.

From early times until the present day many different methods for the control of Itten-O-Meiga" have been devised and applied in the field. In Japan much more progress has been made than in other countries, since great anxiety has been felt that the annual loss of rice, injured by "Itten-O-Meiga", might possibly cause a shortage of this food supply. The different methods of control which have been adopted at different times and in different places are given under

...ually very irregular, and probably the number of genera... is four, or less than four.

...ond is *Nonagria* (*Sesamia*) *inferens* Walk, which sometimes ...stems and young ears which have begun to shoot. It ...them from the outside, and very rarely bores into the ...tly the same way as "Itten-O-Meiga". It is also a ...eder, frequently occurring on sugar cane, teosinte, corn, ...a, Bengal grass, sorghum, etc., growing in the fields. ...sometimes occurs very abundantly in the rice fields, so ...dly plants are ruined entirely by it.

...owing list shows the classific determinations of each ...ifferent species:—

1. Belonging to the Family *Pyralidae.*

a. to the Subfam. *Schoenobiinae*.....*Schoenobius incertellus* Walk.

b. to the Subfam. *Crambinae*···*Chilo simplex* Butl.

2. Belonging to the Family *Noctuidae*, Subfamily *Trifinae*.....*Nonagria inferens* Walk.

1. Found on the surface of the leaf, usually near the apex,

a. With covering hairs···*Schoenobius incertellus.*

b. Without hairs.....*Chilo simplex.*

2. Found usually on the inside of the sheath, without hairs and very irregular in shape..... *Nonagria inferens.*

1. With longitudinal lines,

a. Dorsal and stigmal lines only appear, but both are indistinct.....*Nonagria inferens.*

b. Dorsal, subdorsal and stigmal lines appear, but the latter slightly distinct···*Chilo simplex.*

2. Without longitudinal lines.....*Schoen. incertellus.*

1. Found between the stem and the sheath, very

separate headings.

### A. Selection of Special Varieties of Rice Plant.

About fifty years ago it was discovered by Mr. Sohei Masuda, at Fukuoka, Japan, that the injury varied greatly in different kinds of paddy plant, and he thought that the damage done by "Itten-O-Meiga" (and also *Chilo simplex*) could be decreased by the cultivation of special varieties of rice; and later he announced that "Itten-O-Meiga" could be effectively control by the cultivation, in each districts, of such varieties of the rice plant as have been ascertained to be almost free from attack in the district.

After further experiments by many students, in different localities in Japan, it was unfortunately found, that the kinds of rice avoided by "Itten-O-Meiga" were almost always of inferior quality, and the people did not like rice of such poor quality. Although this method was at one time advocated and put into practice by farmers in a few districts of Kiushiu, it has since been abundoned.

### B. Gathering the Injured Stalks.

Ever since the damage to rice plant caused by this insect, has been noticed by people, in Japan, the "white ears" and bleached stems have been cut off at the lowest part of the stem, and destroyed with a view to reduce the damage. The Japanese farmers have, however, thought it too much trouble to bend down and cut the stalks properly at their base, and although various kinds of hooks have been invented to save trouble to the farmers, little benefit has accrued to the crops, probably owing to carelessness, and the farmers began gradually to doubt if they were reducing the damage, by actually destroying the larvae or pupae, and the practice of gathering the "white ears" and bleached stems (=destroying the larvae and pupae) has now entirely fallen into disuse. Recently, however, this method has again been advocated by several Economic Entomologists in Java, India, the Malay Federated States, Siam and the Philippines; but it is not known whether it has been adopted by farmers.



### C. Collecting the Egg-clusters.

About 36 years ago the collecting and destruction of the eggs of "Itten-O-Meiga" was commenced, in the district of Fukuoka-Ken, Japan, since then this method of checking attack has been actively pursued by the farmers. For a long time, the egg-clusters were only sought in the rice beds, but three or four years ago, it was noticed by Mr. K. Nakagawa that collecting the egg-clusters, as a means of reducing damage, is much more effective after the paddy has been removed from the beds and planted out in the fields. Since this has been known the egg-clusters have been carefully collected both in the beds and in the fields, and has certainly checked the increase of the pest.

In Formosa, a large annual grant is made by the Government to encourage the collection of the egg-clusters in the fields of the southern part of the Island, where the egg-clusters are now collected in great numbers.

Abroad also, this method has recently been advocated by Economic Entomologists, but with what result is at present unknown.

### D. Destruction of Moths by Trap-lanterns.

As the perfect insect is known to be attracted to light in great number, trap-lanterns are used by farmers, wherever the species occurs, excepting perhaps, abroad, where, although this method has been advocated, it has not yet been practised by the farmers. In Japan, there are about three hundred kinds of trap-lanterns all patented; such an evident demand for light-traps indicates how actively this method of destruction is spreading throughout tbe Empire. These trap-lanterns usually consist of a simple lantern and a circular tin pan; the former is an ordinary oil lamp and is placed in or put up the centre of the pan, which is an inch or two deep, and is partly filled with water, which is added some petrol or other mineral oil. Some of lamp-traps have a complicated series of tin or glass reflectors, but they are usually very small, about 18 inches being the diameter of

the pan, and the height of the lantern is about two feet. The simplest form of trap-lanterns will very often kill about 200 moths in a night, and although these traps were employed in great numbers for several years in many different localities, no appreciable diminution in the damage resulted, and the farmers have now almost ceased to use trap-lanterns in Japan and Formosa.

### E. Burning the Paddy Stubble.

From the fact that the larvae hibernate in the rice stumps, Mr. Sohei Masuda concluded that burning the paddy stubble after the harvest has been gathered, must destroy all the larvae or pupae, and therefore prevent occurrence of the first generation of "Itten-O-Meiga" in the following Spring, and he most strongly advocated the employment of this method which the government adopted enforcing it strictly in the three counties of the Province of Fukuoka-Ken(Yame-Gun, Sancho-Gun and Sanmon-Gun), during the Winter of the year 1880. The measure, however, could not be carried out successfully for in some districts the farmers opposed the introduction of the new method, grumbling because the labour involved in digging up the stubble by the roots is very great, the soil being mostly clay; and at one time, a serious rising was feared by the government. In some districts, however, where burning the stubble was enforced and adopted by the farmers, "Itten-O-Meiga" disappeared almost entirely for several years.

After some years a renewed attempt to diminish the pest by same method has been undertaken in Japan, where, although there is still some opposition, and although the effects have been only partially successful, it has been determined to continue these efforts, hoping for eventual success.

So far as Formosa, is concerned, no statistics showing really successful results can yet be produced, but such records of field experiments as have been available have shown good results.

The adoption of this method has been advised by all Economic



Entomologists abroad, but it is unknown to what extent it has been practised. As an alternative it was suggested that burning the stubble standing in the fields would be sufficient to destroy the larvae and that digging up the paddy roots was unnecessary, but in practice it has been found that the stubble is rarely burnt so low as to destroy the larvae hibernating in the stems below the ground, and this method has been generally abandoned in Japan, although it is still practised in some few districts.

### F. Burying the Paddy Stubble.

Shortly after the destruction of the roots by burning had been undertaken in Japan, it was suggested that instead of burning the roots these should be collected and buried in deep pits, or that the stubble should be ploughed in deeply-these methods have been practised in several districts with successful results, being believed by the farmers.

### G. Submerging the Paddy Stubble.

It had been observed that, in marshy localities where the fields were submerged throughout the year, "Itten-O-Meiga" rarely occurred, and an attempt to destroy the pest by artificially flooding other fields throughout the winter was undertaken in a few places in Kagawa-Ken, and in some other parts of Japan, and on a single field in Formosa—whether the results were commercially successful has not been made know.

### H. Cutting-down the Paddy Stubble.

As has been already mentioned serious difficulties have been encountered in the endeavour to control the pest by burning or burying the paddy stubble, and for some years Mr. Sohei Masuda paid special attention to these difficulties hoping to discover some simpler means of control, and eventually he discovered that in certain districts where the rice plants were always cut low in reaping "Itten-O-Meiga" was much scarcer than in other localities where the stubble was left standing higher. He therefore advocated going over the stubble again after the harvest and cutting them down to below the level of

the soil. He pointed out that although this would entail some extra labour, the farmers would save later when ploughing the field preparatory to the cultivation of the aftercrops, which would be much lighter work where the stubble had been already cut, than had previously been the case, where the cutting down of the paddy stumps after the harvest had not been practised, and after this new method of control had been adopted he was able to show that the occurrence of the pest diminished. Mr. Sohai Masuda advocated cutting the stubble low in the province of Fukuoka-Ken, so long ago as 1882, and endeavoured to convince the rice-cultivators of the benefits which would accrue from the adoption of his method. After a little while Masuda's method was commonly practised in several counties of Kiushiu, and at the present time it is recognised to be a valuable special control-measure in Fukuoka-Ken, Saga-Ken and Nagasaki-Ken.

A Japanese iron-headed hoe and reaping hook were at first used to cut the stump, but now several sorts of hoes been invented and patented, showing how generally this method is now practised. The method has not yet been adopted in Formosa, and there are still some localities in Japan where it has not yet been put into practice.

### I. Trapping Larvae moving from Cut-off Stems.

In the year 1905, Dr. K. Sato observed that although the larvae of *Chilo simplex* (and of "Itten-O-Meiga"), usually pass the winter in the paddy stalks after the reaping, they may also be found in stems of corn, sorghum and other gramineous plants, into which they have crawled to hibernate. In the Journal of the Agricultural Society of Japan (Dainippon Nokwai-Ho, March, 1905) he stated that if when storing the paddy straw, stems of corn, sorghum, etc. are mixed with the paddy stems, most of the larvae of *Chilo simplex* will leave the rice stems and may be collected in the other stems and burnt—this should prove a most efficient control for *Chilo simplex*, and probably also for "Itten-O-Meiga".

This method has not been indicated by anyone else and is not



practised, and although it may be a control-measure for *Chilo simplex*, it can hardly prove successful with the larvae of "Itten-O-Meiga" which hibernate in the stem below the ground.

### J. Application of Poisons.

It is the general opinion of both Economic Entomologists and farmers that the larvae can not be successfully poisoned, since they bore in the interior of the rice stems and feed within them, out of insecticides. When the larvae are very young(immediately after the hatching), or when they are moving to other stems, some influence might be produced by spraying with poisons, but in practice the difficulty of ascertaining when the insecticides should be applied has prevented the adoption of spraying.

It has been suggested by some agriculturists that the larvae might be killed by causing the paddy plant to absorb certain poison, but this was not found practicable.

## II. EFFECT OF THE DIFFERENT METHODS OF CONTROL.

A general account of the different methods of control adopted from time to time and their results has already been given under different headings. It is very difficult, if not impossible, to determine with exactitude the actual effect of each method of control, but an attempt to approximate the results so far as they can be ascertained is given in the following headings:—

### A. Selection of Special Varieties of Rice Plants.

It is sometimes found that a certain variety of a particular plant is more or less immune from the attacks of a particular pest than are other varieties of the plant, its cultivation involving no extra expense, but so far no kind of paddy has been found in Japan or Formosa, which is reasonably free from the attacks of "Itten-O-Meiga", although such varieties have been diligently sought. The following observations are based on both crops of many varieties of rice grown in the same in field, each variety being cultivated separately in a plot six feet square:—

Table XLVII. Percentage of stems infested by "Itten-O-Meiga" at Taihoku (Formosa), 1909-1911.

| Variety of rice, 1st. crop. | Average percent. infested. | Variety of rice, 1st. crop. | Average percent. infested. | Variety of rice, 2nd. crop. | Average percent. infested. | Variety of rice, 2nd. crop. | Average percent. infested. |
|---|---|---|---|---|---|---|---|
| | % | | % | | % | | % |
| Shinriki. | 2.2 | Ukoku. | 0.5 | Kakushi. | 2.0 | Banshi. | 0.4 |
| Miyako. | 0.7 | Tanko-Hoirei. | 0.6 | Seikosen. | 0.2 | Saishikoku. | 1.9 |
| Yedo. | 3.2 | Kokiaku-Hoirei. | 1.7 | Ahen. | 0.4 | Banseiyu. | 1.2 |
| Nakamura. | 1.7 | Kokiaku-Ukoku. | 0.1 | Seikogan. | 1.2 | Tenrai. | 0.5 |
| Homashi. | 1.6 | Bokakiu. | 1.4 | Uko. | 0.1 | Nenshi. | 1.2 |
| Kinchaku. | 2.9 | Teikiaku-Hoirei. | 0.9 | Seikasen. | 0.2 | Uto. | 1.3 |
| Sangoku. | 2.1 | Tankiaku-Hoirei. | 1.9 | Kinko. | 0.2 | Kokaku-Kakushi. | 1.8 |
| Shirodokai. | 1.8 | Riushiu. | 0.8 | Osen. | 0.3 | Kakiaku-Kakushi. | 1.6 |
| Saga-Mansaku. | 2.6 | Chikushikiu. | 0.5 | Senko. | 2.4 | Jiugetsuto. | 1.2 |
| Kingioku. | 1.9 | Seiyu. | 3.1 | Banshi. | 1.3 | Ukoku-Bankiu. | 2.3 |
| Chikuseisen. | 2.9 | Seiriu. | 2.7 | Usen. | 0.1 | Gatankiu. | 2.3 |
| Shirafuji. | 2.5 | Ukoku-Riushiu. | 3.3 | Kikushi. | 0.6 | Hakkoku-Kinko. | 0.9 |
| Shirodama. | 1.6 | Ukoku-Nanshi. | 0.6 | Kato. | 1.4 | Taiho. | 1.8 |
| Nippon. | 3.1 | Bichio. | 2.2 | Soko. | 2.0 | Ren. | 1.3 |
| Seigoku. | 1.8 | Nanshi. | 0.5 | Sairiu-Kakushi. | 1.1 | Kitoshi. | 0.8 |
| Chikushi. | 3.2 | Kato. | 0.6 | Seikosen. | 0.4 | Sanpai (I. crop). | 1.0 |
| Unen. | 1.6 | Usenkiu. | 0.7 | Sokoso. | trace | Ushiu-Nanshi (″). | 2.1 |
| Teikiaku-Ukoku. | 1.3 | Saishi. | 3.0 | Kashio-Kakushi. | 1.4 | Boka (″). | 0.3 |
| Toshi. | 0.9 | Teikaku-Usen. | 0.7 | Seikokaku. | 0.05 | Hoirei (″). | 5.4 |
| Kobi. | 4.3 | Ushiu. | 1.7 | Suitan. | 1.9 | Kashio-Usen (″). | 1.9 |

Although this table shows that some varieties are infested much less than others, the percentage of infested stems varied somewhat considerably in each variety in different years. In one instance, the percentage infested, of the variety, "Kokiaku-Hoirei", varied from 0% in 1909 to 3.5% in 1911, while in another variety, "Shinriki", it varied only from 2.1% to 2.3%. This table also shows that in



general, the more valuable varieties are unfortunately much more heavily infested by "Itten-O-Meiga" than the less valuable ones, and also, that no variety is known which is not infested by this insect, and consequently the amount of damage done by "Itten-O-Meiga" cannot be reduced by cultivating special varieties of paddy.

It has been observed that while an injurious insect may show a preference for a particular variety of a plant, yet if variety which seem to be disliked alone are cultivated the pest will gradually accustim itself such varieties and there will be no diminution of the damage done.

In most cases injurious insects feed on several different food plants, but up to the present time "Itten-O-Meiga" has not been found feed on any other plant than rice.

### B. Gathering the Injured Stalks.

This method of control relies upon the collection and destruction of all bleached stalks and "white ears" — these do not all contain "Itten-O-Meiga", but the larvae will be found to be present in the proportion of one in every two or three such stems, for it should be remembered that the larvae move from stem to stem. Since the injured stems usually contain full-grown larvae which would do little further damage before pupation, it is obvious that any benefit derived from destroying these stems will not be apparent until the next crop when a considerable diminution in the number of "white ears" should be expected.

Taking into careful consideration the destruction of "Itten-O-Meiga" in all its stages, through the agency of natural enemies, predaceous or parasitic, it may be assumed that from the eggs laid by each female, fourteen moths may be expected to emerge, and these in their larval stage will have injured more than twenty-eight rice stems.

### C. Collecting the Egg-clusters.

When relying on the collection of the egg-cluters as a method of

control it should be borne in mind, that, as there are two or three generations of "Itten-O-Meiga" during the growth of the rice plants of each crop, the effect produced on the crop by collecting egg-clusters before, at, or after the shooting period will be very different. When the egg-clusters are deposited on very young plants the larvae will cause a proportion of the shoots to die down, but the plant will throw up fresh shoots and be little the worse for the injury; while, on the other hand, the larvae hatched from eggs laid immediately before the shooting period will seriously check the plant, which will be unable to make new growths and the result will be the familiar "white ears". Larvae hatching from egg-clusters deposited after the shooting period do only slight damage to the crop.

Collecting the egg-clusters as a control-measure has been seriously undertaken in Japan but without any great advantage to the crops, owing no doubt to the fact that the eggs were collected only in the rice-beds, while had they been collected, as in Formosa, from the plants in the fields immediately before the shooting period very great beneficial results would have been obtained as shown by the following table:—

**Table XLVIII.** Effect of collecting the egg-masses before the shooting period, in rice fields in Formosa, 1909—1911.

| Year | Locality and crop. | Area examined. | Number of white ears. | | Quantity of yields. | | Quantity of yields (3000 Tsubo) | |
|---|---|---|---|---|---|---|---|---|
| | | | Field where egg-masses collected. | Field where egg-masses not collected. | Field where egg-masses collected. | Field where egg-masses not collected. | Field where egg-masses collected. | Field where egg-masses not collected. |
| 1909 | Hozan 2nd. crop. | Tsubo # 146 | 321 | 662 | Sho × 81.83 | Sho × 71.13 | Sho × 1746 | Sho × 1443 |
| 1910 | Taichiu 2nd. crop. | 300 | 104 | 627 | 454.90 | 403.90 | 4549 | 4039 |
| | Hozan 2nd. crop. | 10 | 465 | 698 | 6.96 | 5.63 | 2088 | 1691 |

# ··· 'Tsubo' = 35.585 square feet; × ··· Sho' = 3.1745 pints.



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1911 | Taichiu 1st. crop. | 123 | 2450 | 4850 | 195.57 | 76.87 | 2316 | 1833 |
| | Taichiu 2nd. crop. | 150 | 2335 | 3613 | 300.73 | 225.52 | 6014 | 4510 |
| | Hozan 1st. crop. | 10 | 346 | 513 | 10.75 | 9.29 | 3227 | 2787 |

Note: During one week shortly before the shooting period all the egg-masses, that could be found, were collected in a field, and after the shooting period the "white-ears" occurring in this field were counted. At the same time the "white ears" occurring in another field, which appeared to be the most slightly injured in the district (but from which the egg-masses had not been collected) counted for comparison (the area in both instances being exactly the same).

The above table shows that if the egg-clusters are carefully collected in the rice fields during the week preceding the shooting period, the normal damage done by the insect will be reduced about one half.

In Japan, it has been calculated by Mr. Nakagawa, that if the egg-masses are collected in the rice fields every third day from August 10th. to September 10th., the yield of rice will probably be increased about four Sho per Tsubo. These detailed results have been given in Dainippon Nokai-Ho, no. 330.

This control-measure appears to vary in effect according to the different stage of growth of the paddy plant. The benefit to the crop increases gradually until the shooting period, after which the utility of collecting egg-masses is found to decrease gradually-this is especially the case in Formosa and perhaps in other subtropical or tropical countries.

In the rice beds the egg-masses are always abundant, but the larvae hatched from these rarely attain the perfect state, even if removed to the fields with the young shoots, as has been already mentioned. It frequently happens that egg-masses laid on the young

shoots are removed with the young plants to the fields, where they hatch, but rarely produce moths, the larvae usually dying from want of food or from the too great depth of the irrigation water, which must always be deep enough almost to cover the young shoots in Formosa.

It must also be remembered, that the rice-bed is made on part of the rice field and the young larva is therefore able to travel from the bed to the field. If the collection of egg-masses in the rice bed is really effective, it must prevent the occurrence of such larvae. Although many of the young shoots growing in the beds are injured by young larvae, there has been so far no scarcity of young shoots for planting out, in Formosa, and probably not in Japan.

From the above it would seem that the collection of egg-clusters in the rice beds is not generally effective.

### D. Destruction of Moths by Trap-lanterns.

It is probably impossible to determine by maens of experiment whether as a method of control trapping by lanterns is efficacious or not. The general idea of our people is that it must be very effective because the moths are captured in great numbers by trap-lanterns. Indeed, few, if any, species of injurious insects are more abundantly trapped by light than is our rice Pyralid. In Japan, this method has been practised continuously for from five to ten years, or perhaps longer in some localities, and numberless moths are annually destroyed by means of light traps. Unfortunately no effect seems to be produced on the yield of crop, certainly this control-measure is not causing "Itten-O-Meiga" gradually to decrease in numbers.

Careful consideration leads us to think that the number of moths destroyed by means of trap-lanterns must be a very small percentage of those which emerged from the pupae, and that the probability of capture by light trap must be much less than that of destruction by natural enemies.

### E. Burning the Paddy Stubble.

The larvae of "Itten-O-Meiga" hibernate only in the paddy st-



umps, and cannot live in the stems which are stored as has been already mentioned. Therefore, complete destruction of the paddy stubble by fire after the harvest of second crop must be absolutely effective and a number of successful results have been observed, but the burning must be very carefully carried out, or there will be no good result, as will be discussed in the *Conclusion*. When the stubble standing in a natural condition was burned, after being covered with straws, the results were scarcely ever really effective, as shown by experiments in Formosa, in 1912.

The results are summarised as follows:—

**Table XLIX.** Percentage of larvae killed by burning the paddy stubble which was standing in a field.

| Locality. | Height of stumps. | Number of stumps which examined. | Number of larvae in stumps. | | | Percentages of larvae which killed. |
|---|---|---|---|---|---|---|
| | | | Living. | Dead. | Total. | |
| | inches | | | | | % |
| Taihoku. | 12 | 100 | 25 | 7 | 32 | 18.92 |
| | 8 | 100 | 56 | 11 | 67 | 16.42 |
| | 5 | 100 | 70 | 11 | 81 | 13.58 |
| Taichiu. | 6 | 98 | 128 | 24 | 152 | 15.78 |
| | 3.5 | 98 | 243 | 34 | 277 | 12.27 |
| | 1.2 | 98 | 113 | 25 | 138 | 18.11 |
| | ? | 98 | 206 | 30 | 236 | 12.71 |
| Hozan. | ? | 100 | 126 | 30 | 192 | 15.20 |

In this experiment a paddy field which had been much injured by "Itten-O-Meiga" was chosen in each of the different provinces, and the irrigation water was completely drained off. After the harvest, the field was covered with all the dried straws which had been reaped in the field, and was set on fire, and the larvae killed were found to be inflated almost to bursting.

The above table shows that the hibernating larvae are killed by such a fire at about the rate of 12 to 18 per cent. The percentage

of larvae killed thus, would, apparently, be much less than the percentage destroyed by natural enemies, etc., during the hibernating time, and this control-measure does not give sufficient results, since it is practically impossible to use enough straw to destroy the larvae in great numbers.

Burning the standing stump does not appear to be really effective, for the hibernating larvae usually occur in the green living roots which contain a good deal of moisture which protects the larvae and most of them escape injury. If burning the stubble is deferred until it is quite withered and dry (about April in the North and February in the South) the moths will have already emerged and there will consequently be no returns for the farmer's labour and expences.

## F. Burying the Paddy Stubble.

From table XXIV it may be concluded that burying the paddy stubble is absolutely effective if it is practised with sufficient care. So far as Japan and Formosa are concerned removing and burying the stumps, or burning them, have been proved to be absolutely effective measures of control, but no part of the roots must be left undisturbed as the larvae of "Itten-O-Meiga" are often found in numbers in the lowest parts of the roots as shown in the following table, which summarizes the results of experiments:—

**Table L.** Percentage of paddy stumps broken when pulling up by the roots, part being left in the soil (estimated in Formosa, in each instance on 100 stumps).

| Year. | Locality. | Date when examined. | Time spent. | Number of broken roots. | Number of larvae left in roots remaining in soil. | Percentage of broken roots. | Condition of land. |
|---|---|---|---|---|---|---|---|
| 1909 | Hozan | 21st. Nov. | 5m. 5s. | 3 | 0 | 3 | Heavy clay soil, moist. |
| | | 19th. Dec. | 5' 3" | 5 | 2 | 5 | Heavy clay soil, dried up and cracked. |
| | | 19th. Jan. | 5' 2" | 9 | 3 | 9 | do. |
| | Taihoku | 16th. Nov. | 7' 5" | 6 | 0 | 6 | Heavy clay soil, hardly dried up. |
| | | 17th. Dec. | 5' 6" | 17 | 0 | 17 | Heavy clay soil, moistened by rains after drying. |



| Year. | Locality. | Date when examined. | Time spent. | Number of broken roots. | Number of larvae left in roots remaining in soil. | Percentage of broken roots. | Condition of land. |
|---|---|---|---|---|---|---|---|
| 1910 | Hozan | 24th. Nov. | 8m. 13s. | 1 | 0 | 1 | Heavy clay soil, dried up and cracked. |
| | | 17th. Dec. | 8' 3" | 0 | 0 | 0 | do. |
| | | 20th. Jan. | 6' 4" | 2 | 0 | 2 | do. |
| | Taichiu | 15th. Nov. | 8' 2" | 7 | 3 | 7 | Clay soil, dried up. |
| | | 16th. Jan. | 4' 25" | 8 | 5 (pupae) | 8 | do. |
| 1911 | Taichiu | 30th. Nov. | 7' 5" | 0 | 0 | 0 | Heavy clay soil, moist. |
| | | 19th. Dec. | 5' 8" | 5 | 1 | 5 | Heavy clay soil, dried up and cracked. |
| | | 20th. Jan. | 4' 10" | 19 | 2 (pupae) | 19 | Heavy clay soil, moistened by rains after drying. |
| | Hozan | 17th. Nov. | 10' 11" | 2 | 1 | 2 | Heavy clay soil, dried up and cracked. |
| | | 19th. Dec. | 10' 11" | 4 | 0 | 4 | do. |
| | | 23rd. Jan. | 9' 0" | 7 | 4 (pupae) | 7 | do. |
| | | 17th. Nov. | 5' 0" | 0 | 0 | 0 | Light clay soil, dried up. |
| | | 19th. Dec. | 5' 0" | 4 | 3 | 4 | do. |
| | | 20th. Jan. | 5' 0" | 12 | 7 (pupae) | 12 | do. |

From this table it is obvious that unless the roots are removed entire and buried (or burnt) all the hibernating larvae will not be destroyed, and also that this method is less effective as the season for preparing the fields for the next crop approaches when the roots begin to rot and they cannot be pulled up without breaking them. It is therefore most important that immediately after the stumps have been pulled up by the roots the holes in the ground should be filled with mud or fine soil with a view to destroy any larvae left behind in pieces of the roots.

## G. Submerging the Paddy Stubble.

If the rice fields are flooded immediately after the harvest and the water is left standing sufficiently deep on the stubble until the time for the preparation for the next crop the results contained will be quite as effective as by the two preceding methods of control as shown in Tables XX and XXIII.

In Formosa, it was found that although flooding the fields did not kill the larvae it had a retarding effect preventing them from pupating while the stumps were under water, this system should therefore be employed to prevent the larvae transforming and the moths escaping before the preparation of the field for the next crop when all the larvae and pupae in roots should be destroyed by ploughing up and burying the stubble.

In Japan, it is well known, that the hibernating larvae almost always die when the stumps are flooded, and that in Nagasaki-Ken (see the Report of the Agricultural Experiment Station, Nagasaki-Ken, no. XIII) they cannot live in damp fields. Probably low temperatures during the winter may account for the different results obtained in Japan as compared with my experiences in Formosa. The percentage obtained from observations in Japan are given below:

**Table LI.** Percentage of dead larvae (from the Special Report of the Agricultural Experiment Station at Kagawa-Ken, 1911).

| Area. | Series of observations. | Number of larvae in paddy stumps. | | Percentage of dead larvae. |
|---|---|---|---|---|
| | | Living. | Dead. | |
| Tsubo | | | | % |
| 10 | Stubble standing in ordinary condition submerged. | 0 | 29 | 100 |
| 10 | Stubble ploughed and submerged. | 1 | 50 | 98 |
| 10 | Stubble buried and submerged. | 0 | 59 | 100 |
| 10 | Stubble ploughed. | 31 | 56 | 68 |
| 10 | Stubble left in ordinary condition. | 25 | 23 | 48 |

## H. Cutting-down the Paddy Stubble.

The results obtained by cutting-down the paddy stubble vary much according to the amount of skill and care exercised by the farmers, the various implements used, the nature of the soil, the condition of the stubble (whether green or withered), and also the number of times the stumps are cut-down during the season.



During the past three years, 1909—1911, many observations were made with a view to ascertain the value of this method of control. The following table shows that the results obtained by cutting-down the stumps, in the ordinary fields, to an inch below the surface of the soil with an ordinary Formosan hoe once during the season.

**Table LII.** Results from cutting-down the paddy stumps in Formosa.

| Year. | Locality. | Number of stumps examined. | Percentage of larvae destroyed by the hoe. | Percentage of larvae found in the cut-off stems. | Percentage of larvae left in the roots. | Notes. |
|---|---|---|---|---|---|---|
| | | | % | % | % | |
| 1909 | Taihoku | 17 | 21.2 | 57.6 | 21.2 | 2nd. crop, experiment made, 17. and 18. November. |
| | Taichiu | 100 | 68.4 | 6.5 | 25.1 | 2nd. crop, experiment made, 26 November. |
| | Hozan | 32 | 32.9 | 45.5 | 21.6 | Kanten-Den, experiment made, 20. December. |
| | Hozan | 40 | 29.4 | 43.1 | 27.5 | 2nd. crop, experiment made, 11 days after the harvest. |
| | Hozan | 40 | 34.1 | 38.8 | 27.1 | Kanten-Den, experiment made, 10 days after the harvest. |
| 1910 | Taihoku | 107 | 27.1 | 20.7 | 52.2 | Experiment made immediately after the harvest of the 2nd. crop. |
| | Taichiu | 100 | 51.8 | 39.6 | 8.6 | do. |
| | Hozan | 40 | 10.8 | 1.8 | 87.4 | do. |
| | Hozan | 70 | 11.8 | 5.1 | 83.1 | Kanten-Den, experiment made immediately after the harvest. |
| 1911 | Taihoku | 43 | 30.5 | 12.5 | 57.0 | 2nd. crop, experiment made immediately after the harvest. |
| | Taichiu | 100 | 57.2 | 8.7 | 34.1 | do. |
| | Hozan | 100 | 30.6 | 18.6 | 50.8 | do. |
| | Hozan | 100 | 21.5 | 54.2 | 24.3 | 2nd. crop, experiment made, 31 days after the harvest. |
| | Hozan | 60 | 22.6 | 11.3 | 66.1 | Kanten-Den, experiment made, 5 days after the harvest. |

The table shows that the percentage of larvae actually killed by the hoe varies as much as from 10.8% to 68.4%, the variation

being occasioned as follows :—

Fields showing only a small percentage of larvae killed by the hoe mostly of heavy clay soil, where there was extreme difficulty, in cutting down the stumps to a sufficient depth with the hoe.

The effect produced by hoeing must not be limited to the percentage of larvae actually killed, for to this number must be added the percentage of larvae cut-off in the stems since we have proved by careful observation that larvae which have spun their cocoon for pupation are invariably unable to pupate and all of them die. Younger larvae in the cut-off stems occasionally endeavour to enter the stumps remaining in the soil, but they are very rarely able to do so.

The table above shows that the number of hibernating larvae destroyed by cutting-down the stumps varied from 12 to 91 per cent.

Many observations have also been made in various parts of Japan, and the following table showing the average percentages of larvae destroyed by the hoe has been compiled from these records :—

**Table LIII.** Results from cutting-down paddy stumps in Japan.

| Locality. | Percentage of larvae killed by the hoe. | Notes. |
|---|---|---|
| Kagawa. | 50-87 % | From the Spec. Report of the Agr. Exp. Stat., Kagawa-Ken, 1907 and 1911. |
| Kumamoto. | 16-47 | From the Report of the Agr. Exp. Stat., Nishigahara, Tokio, no. 31. |
| Nagasaki. | 35-60 | From the Report of the Agr. Exp. Stat., Nagasaki-Ken, no.13. |
| Yehime. | 44-8 | From the Spec. Report of the Agr. Exp. Stat. Yehime-Ken, no. 2. |

It has been frequently observed in the field, both in Japan and Formosa, that larvae hibernating in very short stumps are often unable to pupate and emerge, and notes were carefully made with a view to ascertain the percentage of moths resulting the larvae left in the stumps after the paddy had been cut down as a method of control as compared with the percentage of moths emerging from the untouched



stumps. The results of the observations made in Formosa and Japan are shown in the following table :—

**Table LIV.** Percentage of hibernating larvae failing to emerge as moths.

| Locality. | Condition of the stumps. | Death rate among hibernating larvae. | | | | |
|---|---|---|---|---|---|---|
| | | 1908 | 1909 | 1910 | 1911 | Average |
| | | | % | % | % | % |
| Taihoku. | Cut stumps. | .... | 99.82 | 100.00 | 99.99 | 99.93 |
| | Ordinary stumps. | .... | 85.24 | 59.98 | 78.35 | 81.74 |
| Taichiu. | Cut stumps. | .... | 91.72 | 98.27 | 100.00 | 96.67 |
| | Ordinary stumps. | .... | 73.51 | 83.77 | 46.31 | 67.86 |
| Hozan. | Cut stumps. | .... | 87.81 | 89.25 | 93.21 | 90.09 |
| | Ordinary stumps. | .... | 82.50 | 77.93 | 81.53 | 80.65 |
| Formosa. | Totgl average. Cut stumps. | % 95.56 | | | | |
| | Total average. Ordin. stumps. | 76.75 | | | | |
| | | % | | | | |
| Nagasaki Japan. | Cut stumps. | 87.70 | 100.00 | 100.00 | .... | 95.90 |
| | Ordin. stumps. | 83.29 | 67.86 | 98.89 | .... | 83.35 |

The above table shows that the death-rate of larvae left in the cut-down stems is from 10% to 58% greater than among those in natural conditions in the untouched stumps, and it may be safely concluded that if the cutting-down of the paddy stumps is carefully practised immediately after the harvest (i. e. during the hibernating period), from 86% to 100% of the hibernating larvae will be destroyed.

## I. Trapping Larvae moving from Cut-off Stems.

Although it was fairly obvious, from what was already known, that any system of trapping the larvae in the cut-off stems would be of little use as a method of control, yet it was thought advisable to ascertain how many larvae of "Itten-O-Meiga" (and also of the other rice-borers) would be actually trapped during the season. The results are shown in the following table :—

Table LV. Paddy borers trapped in Formosa, 1608.

| Plant used as trap. | Where placed. | Number of larvae trapped. | | | |
|---|---|---|---|---|---|
| | | *Chilo simplex.* | *Schoenobius incertellus.* | *Sesamia inferens.* | Total. |
| Sugar cane. | On upper surface of heap of rice-straw. | 1 | 2 | 14 | 17 |
| *Zizania latiforia.* | do. | 10 | 0 | 20 | 30 |
| Teosinte. | do. | 1 | 0 | 15 | 16 |
| Sugar cane. | Inside of heap, 2 feet below the surface. | 0 | 0 | 3 | 3 |
| *Zizania latiforia.* | do. | 10 | 0 | 16 | 26 |
| Teosinte. | do. | 0 | 0 | 16 | 16 |
| Sugar cane. | Inside of heap, 4 feet below the surface. | 0 | 0 | 0 | 0 |
| *Zizania latiforia.* | do. | 2 | 0 | 8 | 10 |
| Teosinte. | do. | 0 | 0 | 5 | 5 |
| Sugar cane. | Inside of heap, 5 feet below the surface. | 1 | 0 | 1 | 2 |
| *Zizania latiforia.* | do. | 0 | 0 | 0 | 0 |
| Teosinte. | do. | 0 | 0 | 6 | 6 |
| Total. | | 25 | 2 | 104 | 131 |

In these experiments the paddy straws were heaped in the usual way, in round mounds, about nine feet in diameter and about six feet in height, the different trap crops, which are commonly found in Formosa, being thrust inside them, and also placed on the upper surface. Immediately after the harvest both the straws and the trap crops were arranged horizontally, with their tips towards the inside of each heap, and the traps were examined three weeks later, very few larvae being found, the experiment proving a failure as anticipated.

The larvae of *Schoenobius incertellus* were dead, and very difficult to identify with certainty.

### J. Application of Poisons.

The application of certain poisons during the period when the



larvae are hatching or when they are moving from stem to stem would certainly be an effective control for "Itten-O-Meiga", if it could be satisfactorily carried out, but in practice this is almost impossible, for the following reasons:—

Throughout the season the larvae are found in different stages of growth. This is especially the case in Formosa. Rains are also frequent washing the poison off the plants, and it would be necessary to renew the application of the poison every two or three days through the whole growing period of the paddy plants, to obtain satisfactory results.

## III. LABOUR INVOLVED IN THE DIFFERENT METHODS OF CONTROL.

The amount of labour involved in different control measures differs in each case, and in practice the determination of the probable amount of labour required must be one of the most important items.

I will now discuss certain control measures which demand special labour for their employment.

### A. Gathering the Injured Stalks.

Experiments were made to determine the amount of labour involved in the gathering of injured stalks. For this purpose an ordinary rice field was chosen, and at various times tests were made by the farmers of three methods of gathering. In the first and second two instruments in common use in Japan were employed. In the third gathering was done by hand. The following table summarizes the results:—

Table LVI. Labour of gathering the injured stalks in Formosa, 1908.

| Stage of paddy. | Instruments employed. | Hours worked. | Area worked. | Number of the stalks which gathered. | Area worked by a single farmer in eight hours (one day). |
|---|---|---|---|---|---|
| | | | Tsubo. | Withered stems. | Tsubo. |
| Young period, before the shooting. | Cutting hook with a spring. | 1 hour. | 34.8 | 190 | 278 |
| | Cutting hook without a spring. | do. | 31.6 | 180 | 252 |
| | By hand. | do. | 50.0 | 232 | 400 |
| | | | | White ears. | |
| Old period, after the shooting. | Cutting hook with a spring. | do. | 52.0 | 167 | 416 |
| | Cutting hook without a spring. | do. | 36.0 | 125 | 288 |
| | By hand. | do. | 31.6 | 111 | 252 |

It will be noticed that a farmer could gather the injured stalks standing in over 250 Tsubo on a day; and that during the young period of paddy a farmer could gather about 180—232 injured stalks in a day, but after the shooting apparently less than this; and that a difference was apparent, from the employment or nonemployment of instruments. Assuming that there is only one larva found in every three injured stalks, a farmer can destroy about 37 to 77 larvae, (and these will be found in 252 to 416 Tsubo), in a day.

### B. Collecting the Egg-clusters.

The amount of labour involved in the collecting of egg-masses apparently varies according to the different stages of the growth of paddy, and the number of egg-masses collected varies greatly, according to the farmers' skill.

Experiments were made by a farmer, who had previously assisted us two or three times, under careful supervision, during the season which was commonly thought to be the most difficult time to collect the egg-clusters. The results are given below:—



**Table LVII.** Number of egg-masses which collected in 3000 Tsubo, and the hours spent, at Hozan (1909-1911).

| Stage of paddy. | 1909 | | 1911 | | 1912 | |
|---|---|---|---|---|---|---|
| | Number of egg-masses collected. | Hours spent. | Number of egg-masses collected. | Hours spent. | Number of egg-masses collected. | Hours spent. |
| | | hours | | hours | | hours |
| Before the shooting. | 742 | 46.40′ | 63 | 64.40′ | 84 | 53.33′ |
| Shooting period. | 603 | 43.20′ | 161 | 56.30′ | 80 | 66.00′ |
| do. | 508 | 51.40′ | 84 | 48.37′ | .... | .... |
| Immediately after the shooting. | 62 | 36.40′ | 61 | 46.50′ | 100 | 66.00′ |
| do. | 61 | 40.50′ | 60 | 43.30′ | .... | .... |
| Average. | 395 | 43.50′ | 85 | 51.49′ | 88 | 61.51′ |

This table shows that in from 37 to 66 hours from about 61 to 742 egg-masses laid in 3000 Tsubo could be collected by a farmer, and that the hours spent for the collection of the egg-masses in 3000 Tsubo, does not apparently vary according to the number of the egg-clusters. It will be noticed that, before the shooting period, in one day the farmer can collect the egg-masses laid in more than 428—600 Tsubo.

### C. Destruction of Moths by Trap-lanterns.

The practice of this method of control entails very little labour, but farmers do not always care to use it, because the expense incurred for trap-lanterns and oil.

Using the most economical method, five traps are usually employed in 3000 Tsubo; one trap lantern costs on an average, about one shilling. About a farthing a night must be paid for the lighting of each lantern, that is, five farthing for 3000 Tsubo.

### D. Burning the Paddy Stubble.

During the past three years, 1909—1911, experiments were made, employing average Formosan farmers, to ascertain the probable amount of labour entailed in this control measure. In the experiments, the

paddy roots were first dug out or pulled up and then burned after being covered with paddy straws. The following table very briefly summarizes the results :—

**Table LVIII.** Labour and expense involved in the burning of paddy stumps, in 3000 Tsubo, Formosa (1909—1911).

| Locality. | Time. | Series of experiments. | Number of farmers employed. | Quantity of straws spent. | Quantity of petroleum spent. |
|---|---|---|---|---|---|
| | | | | Pounds. | Sho. |
| Taihoku. | Reaping time. | Burning after digging out. | 45 | 480 | 0 |
| | In the 2nd. ten days of December. | do. | 40 | 116 | 0 |
| | Reaping time. | Burning after pulled up. | 36 | 182 | 1 |
| | In the 2nd. ten days of December. | do. | 19 | 0 | 0 |
| | In the 2nd. ten days of January. | do. | 16 | 58 | 0 |
| Taichiu. | Reaping time. | do. | 58 | 579 | 0 |
| | In the 2nd. ten days of December. | do. | 29 | 0 | 0 |
| | In the 2nd. ten days of January. | do. | 13 | 0 | 0 |
| Hozan. | Reaping time. | do. | 34 | 2765 | 3 |
| | In the 2nd. ten days of December. | do. | 16 | 0.4968 | 0 |
| | In the 2nd. ten days of January. | do. | 14 | 0 | 0 |

It will be noticed that the amount of labour and expense involved in this control measure is largest at the reaping time, and gradually decreases according as the time for the preparation of the field approaches. This is due to the fact that when the time for the preparation of the field approaches, the roots have withered so that they can be easily pulled up, and burned. Practically, the effect of burning the stumps diminishes according as it is further from the harvest time ; and, where the stump is pulled up, the lowest portion



frequently remains in the soil, the larvae being very often found in this, as shown in Table L.

This being so, the method of control by which the roots are pulled up is not absolutely effective. But, if the remaining roots are perfectly covered with soil, the effect is the same as in cases where they are dug out.

In Kanten-Den the land after the harvest is almost always so very hard that the paddy stumps cannot be dug out by means of an ordinary hoe ; it is, however, comparatively easy to pull them up.

From the above, it has been concluded that in the lower half of Formosa, the paddy stubble after the harvest should be mostly pulled up instead of being dug out, and experiments were made to ascertain the labour involved in covering such remaining roots. The appended table summarizes the results :—

**Table LIX.** Average amount of labour necessary for covering paddy roots still remaining in the soil, after being pulled up, with mud in 3000 Tsubo, 1909—1911.

| Time. | Average number of farmers employed for covering the remaining roots. | | | |
|---|---|---|---|---|
| | Taihoku. | Taichiu. | Hozan. | Average. |
| Reaping time. | 3 | 27 | 21 | 17 |
| In the 2nd. ten days of December. | 4 | 39 | 22 | 21.7 |
| In the 2nd ten days of January. | 3 | 39 | 18 | 20 |
| Average. | 3.3 | 35 | 20.3 | 19.6 |

This table shows that in the northern part about four farmers are required to do the covering, in the middle part about thirty-five, and in the southern part about twenty. This difference is due to the number of the stumps (roots) remaining after the pulling up. To accomplish the desired results in this control measure, the sum of the amount of labour (and expense) shown in the Tables LIX and LVIII, respectively, is required, excepting in the case in which the roots are

dug out in the northern part. Namely, in the northern part, on an average about 27 farmers are required in 3000 Tsubo for the practice of this method of control (or about 43 farmers in cases where the roots are dug out); in the middle part about 69; and in the southern part about fifty-two. The materials for its practice, in 3000 Tsubo, are about 0.14 gallons of petrol.

### E. Burying the Paddy Stubble.

There are four methods of burying the stubble. The first one is commonly practised in Japan; in this case the roots are dug out by an ordinary iron-headed hoe, and after this they are buried collectively in a hole which is excavated in the field. In Formosa this method can be economically put into practice only in the northern part and in some districts of the other parts. From an experiment in the northern part, it is noticed that ten hours are required for its practice in 3000 Tsubo by about 53 farmers.

The second method is put into practice in land where the roots cannot be dug out, especially in Kanten-Den, in which case the roots are buried collectively after being pulled up, in the same manner as in the first case; and after this the roots still remaining in the soil are covered with mud. Experiments were made in different localities to ascertain the amount of labour entailed as given below.

**Table LX.** Average amount of labour entailed in burying the paddy roots being pulled up in 3000 Tsubo, Formosa, 1909—1911.

| Time. | Average number of farmers employed for burying. | | | |
|---|---|---|---|---|
| | Taihoku. | Taichiu. | Hozan. | Average. |
| Reaping time. | 55 | 71 | 46 | 57.3 |
| The 2nd. ten days of December. | 38 | 46 | 33 | 39.0 |
| The 2nd. ten days of January. | 25 | 38 | 28 | 30.3 |
| Average. | 39.3 | 51.6 | 35.6 | 42.1 |



From this alone, the amount of labour required for the accomplishment of the results desired in this control measure cannot be determined, as has been already discussed in the previous section. Allowance must be made for the labour of covering the roots remaining in the soil after pulling up. Indeed, the sum of the numbers shown in Tables LIX and LX shows the real amount of labour required for the purpose of the method of control.

The third method, which is suitable for use in damp fields, is that of burying the paddy stumps under the soil, by means of ploughing. In practice, all the stumps are not usually satisfactorily buried, in spite of careful ploughing. For this reason, at the same time, unburied stumps are collected and buried in a hole. Experiments were made to determine the propable amount of labour involved, the results giving in the following table:—

**Table LXI.** Average amount of labour entailed in burying the paddy stumps by means of ploughing, in 3000 Tsubo, Formosa, 1909—1911.

| Locality. | Amount of labour. | |
|---|---|---|
| | Number of farmers employed. | Number of buffaloes employed. |
| Taihoku. | 10 | 6 |
| Taichiu. | 12 | 6 |
| Hozan | 17 | 9 |
| Average. | 13 | 7 |

It may be considered that in a damp field about thirteen farmers and seven buffaloes are needed to bury the stubble in 3000 Tsubo.

From all the above, it is probably safe to conclude that in an ordinary field about fifty-three farmers will be required for the burying of the paddy stubble in 3000 Tsubo, in a dry field (for example, in Kanten-Den) about sixty-five, in a damp field (that is, a field which can be ploughed satisfactorily immediately after the harvest) about

17 farmers and about 7 buffaloes#, and in a marshy field about 18 farmers.

### F. Submerging the Paddy Stubble.

This method of control could only be put into practice in a field where an irrigation system has been completely made, demanding a very slight amount of labour. In an ordinary field which could not be irrigated during the winter, this method could not be applied with absolute success.

### G. Cutting-down the Paddy Stubble.

During the past three years (1909—1911) experiments were made to determine the probable amount of labour required for the practice of this control measure in the different localities. The average number of farmers employed for the experiment is given in the following table:—

**Table LXII.** Average amount of labour entailed in cutting-down the paddy stubble, in 3000 Tsubo, Formosa (1909-1911).

| Locality. | Average number of farmers employed, for the cutting. | Average number of farmers employed, for gathering the cut-off stalks. | Average quantity of straw and petrol spent for burning the gathered stalks. | |
|---|---|---|---|---|
| | | | Straw. | Petroleum. |
| Taihoku. | 11 | 7 | 44 pounds. | 1.22 Sho. |
| Taichiu. | 10 | 9 | 50 " | 0 |
| Hozan. | 11 | 11 | 25 " | 0.46 " |
| Average. | 10.7 | 9 | 39.7 pounds. | 0.56 Sho. |

In the experiments, an ordinary iron-headed hoe was employed to cut the paddy stumps about one inch below the soil surface.

From the above summarized table it will be seen that about 11 farmers are required for cutting the paddy stubble in 3000 Tsubo, and also that about nine farmers, using about 40 lbs. of straw and 0.56

# In genaral, buffaloes are employed for the ploughing of the fields in Formosa.



Sho of petrol, will be required for burning the cut-off stalks, if it is necessary.

## IV. RELATION OF THE DIFFERENT METHODS OF CONTROL TO THE YIELD OF RICE.

Since any method of control employed in a given field, changes the conditions, to a certain extent, the paddy plants growing there may be in some degree injured as a result. Indeed, this is one of the most important matters in the selection of an effective control measure, and is the principle point which will be discussed under this section.

### A. Selection of Special Varieties of Paddy Plant.

Although the amount of the damage in a small area may be diminished by selecting special varieties, as has been already pointed out, the variety of paddy disliked by "Itten-O-Meiga" is almost always bad in the quality of the crop, and the quantity is also less than in other varieties which are much more severely attacked by the insect.

### B. Gathering the Injured Stalks.

The opinion is held by many farmers that if the rice field is walked over during the growing season, for the purpose of gathering the injured stalks, the roots of the paddy will be injured and the yield will be diminished. To ascertain if such a belief was true experiments were made throughout the season, on both the first and second crops, at Taihoku, in 1907 and 1908.

In the tests an experimental field of 900 Tsubo was chosen, for each crop, and in each year. The same variety of paddy plant was cultivated in the field (of course the variety differed in the different crop seasons) and treated uniformly till it was reaped. In one third of the area of such a field, a farmer walked along at intervals between each row of paddy plants, from immediately after they were replanted until before the shooting period; in another di-

vision of the field, this was done similarly from the shooting period until the harvest; and in the remaining area, no one was allowed to walk through the field during the season. From the results, it was noticed that there was no diminution of the yield, although the injured stalks were collected from the young period until before the shooting; while in the second area where the injured stalks were collected from the shooting period until the harvest time, on an average from the different crops about 20 per cent of the yield was diminished. This is certainly due to the fact that a great quantity of rice has fallen from the ears, by the walking among the plants, but in Japan there is no variety in which the unhulled rice borne in the ears can be easily removed, as in Formosa.

In short, the practice of this control-measure has no relation to the yield, excepting in Formosa, when it is practised after shooting.

**C. Collectig the Egg-clusters.**

From the experiments shown in the preceding section, it is safe to conclude that the collecting of the egg-masses until the shooting period, causes no damage to the yield.

**D. Destruction of Moths by Trap-lanterns.**

It is well known among many agriculturists that there is no direct relation between the growth of the paddy plant and light at night. Around the places where the lantern traps are placed extremely injured plants are very often found. This is certainly due to the fact that all the moths attracted by light are not satisfactorily trapped. It must be noticed, therefore, that lighting has very often an indirect relation on the growth of paddy.

**E. Burning the Paddy Stubble.**

The paddy stumps must first be dug out or pulled up, as has been already described. This brings us to a consideration of how paddy stubble, as a manure, is changed if it is burned, and also what relation the burning of paddy stubble has on the cultivation of green manure plants.



In the former case, the physical condition of the land will be more or less changed for the worse, as all the stumps standing in it are taken away; however, the land will be indirectly oxygenated by means of the digging or pulling, more than under ordinary conditions. When the ashes from the burnt stubble are scattered on the land, there is scarcely any difference, as a manure. According to my experiments, it is noticed that there is not even a slight difference between the ordinary field and a field in which the control is practised.

In the latter case, it must be considered that green manure plants are cultivated after or before the harvest. In most fields, the former is the rule, and in such fields the sowing time of green manure plants will not be very late, as this would have a bad result no the growth of the manure plant, on account of the practice of the method of control; experiments have plainly shown that it had no effect on the growth, although sowing took place two or three days later than the ordinary time. In Ako district there are abundant fields where green manure plants are cultivated long before the harvest. If the control-measure is put into practice, in those fields, the green manure plants must be cultivated much later than the usual time. Experiments were made ascertain what the results were in such a case. The following table summarizes the results:—

**Table LXIII** Condition of growth of green manure plants, at Ako, Formosa, 1912.

| Series of Experiments. | Kind of green manure plants. | Date when sowed. | Area of field. | Date when germinated. | Average height of the plants on 24th. Decemb. | Date when the plants ploughed in the soil. | Condition of the plants at date of ploughing. | Amount of crops at date of ploughing. |
|---|---|---|---|---|---|---|---|---|
| | | | Tsubo. | | inches. | | | pounds. |
| I | *Sesbania aegyptiaca.* | 29th. Octob. | 10 | 6th. November. | 10.25 | 25th. January. | After flowering. | 45·54 |
| II | do. | 8th. Nov. # | 10 | 17th. November. | 5.22 | do. | Flowering. time. | 17·39 |

\# Rice plants of the second crop are generally reaped in this district until the 5th. November.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| III | *Sesbania aegyptiaca.* | 18th. Novem. | 10 | 24th. November. | 2.35 | 25th. January. | Just before flowering. | 10.77 |
| IV | *Glycine hispida.* | 29th. Octob. | 10 | 4th. November. | 15.42 | do. | Seeds almost perfectly ripend. | 84.46 |
| V | do. | 8th. Novem. | 10 | 15th. November. | 8.58 | do. | With young pods. | 60.61 |
| VI | do. | 18th. Novem. | 10 | 22nd. November. | 1.91 | do. | Just after flowering. | 29.06 |

In the experiments green manure plants which are commonly cultivated by farmers were planted in the ordinary way, and the seeds were sowed at the usual times, only in the first and fourth series. In the field where green manure plants were thus ploughed in, rice plants were cultivated in the next Spring, and the crops from each series were compared, as given below :—

**Table LXIV.** Amount of the yield of first crop from an experimental field thus treated at Ako (Formosa, 1913).

| Series of experiments | Date when the rice plant replanted. | Variety of paddy. | Area of field. | Date when the rice plant reaped. | Amount of crops. | | |
|---|---|---|---|---|---|---|---|
| | | | | | Quantity of unhulled rice. | Weight of unhulled rice. | Weight of straws. |
| | | | Tsubo. | | Sho. | pounds. | pounds. |
| I | 27th. January. | Seiyu. | 10 | 17th. May. | 12 | 26.4 | 42.23 |
| II | " | " | 10 | " | 13 | 27.39 | 45.54 |
| III | " | " | 10 | " | 12 | 26.69 | 45.13 |
| IV | " | " | 10 | " | 12.5 | 25.09 | 43.88 |
| V | " | " | 10 | " | 13.7 | 26.58 | 45.29 |
| VI | " | " | 10 | " | 11 | 24.01 | 41.98 |

The paddy plant, *Seiyu*, is commonly cultivated in the Ako district. From the above two tables it will be noticed that in experimental fields II and V, the crops of rice plant were larger than those in the others, although fewer green manure plants were cultivated, apparently, than in experimental fields I and IV, where the seeds were sown at the usual time. This is due, no doubt, to the



fact that green manure plants were grown beyond the most suitable time for manure plants.

It is safe to conclude that green manure plants can be cultivated after the harvest, in districts where it is believed among the farmers that the green manure plants must certainly be cultivated before the harvest, giving an increased rice crop on this account ; and that the method of control will be satisfactorily put into practice.

### F. Burying the Paddy Stubble.

It may be considered that the practice of this control measure has almost the same relation to the land and to the green manure plants, as in the burning of paddy stumps. But it differs from this, as in the present case, the paddy stumps collected from a large area, are buried in a deep hole, except in the case where the stubble is buried by means of ploughing, and from this fact the nutritive value of the stubble as manure is lost. Experimental cultivations of rice plants were made in different localities, during the past three years (1909—1911), to ascertain what relation this method has to the growth of rice plants ; but there were no effects.

From the above, it will be noticed that the burying of paddy stubble has probably slight effect on the cultivation of rice.

When the burying is done by means of ploughing the soil, the paddy plants cultivated in land thus treated produce larger crops than in an ordinary non-treated field, as shown in Table LXV. Indeed, the effect in such a case is good.

### G. Submerging the Paddy Stubble.

The opinion is held among many agriculturists that a field, when submerged during the winter time, gets into a bad condition in every way, and the rice plants cultivated in such a field produce fewer crops than the non-flooded fields. In middle and southern Formosa, a few tests were made to ascertain if this was so, with the following results :—

Table LXV. Comparative yields from differently treated fields in the first crop (Formosa).

| Locality. | Year. | Condition of the experimental fields during the Winter. | Area. | Amount of crop. | | |
|---|---|---|---|---|---|---|
| | | | | Weight of unhulled rice. | Quantity of unhulled rice. | Weight of straw. |
| | | | Tsubo. | pounds. | Sho. | pounds. |
| Hozan | 1911 | Non-treated. | 10 | 41.73 | 20.13 | 46.29 |
| | | Ploughed. | 10 | 47.80 | 23.21 | 71.46 |
| | | Submerged. | 10 | 41.62 | 18.42 | 51.17 |
| | | Ploughed and submerged. | 10 | 51.53 | 24.51 | 73.69 |
| Ako | 1913 | Non-treated. | 10 | 21.53 | 10.53 | 59.62 |
| | | Ploughed. | 10 | 23.85 | 11.52 | 73.69 |
| | | Submerged. | 10 | 18.22 | 8.91 | 72.04 |
| | | Ploughed and submerged. | 10 | 25.50 | 12.34 | 95.22 |
| Taichu | 1911 | Dried. | 10 | 46.39 | 22.86 | .... |
| | | Submerged. | 10 | 30.64 | 15.75 | .... |

This table shows that the amount of the crops from the submerged field is apparently less than from the others, while in the ploughed and submerged field the crops are more than in the others. From the above, it will be noticed that the flooding of the field during the winter, when ploughing is put in practice at the same time, gives good crop results. However, in the district where a green manure plant is cultivated annually, it had very bad results.

### H. Cutting-down the Paddy Stubble.

A field in which the method of control is practised differs chiefly from the ordinary field, from the fact that the paddy stumps must be cut in smaller pieces. This does not produce any bad results on the growth of rice plant, but rather good effects.

Of course, in districts where green manure plants are cultivated, cutting-down the stump causes more or less delay in the time of sowing. This has been already discussed.

### I. Trapping Larvae moving from Cut-off Stems.



This method may be practised outside the rice field, as has already been explained; and this plainly indicates that it has no relation to the growth of paddy.

### J. Application of Poisons.

The application of poisons sometimes retards the growth of rice plant, especially in Formosa. The degree of injury varies to a large extent according to the poisons used and the time of growth. Of course, in a certain number of instances the treatment has been satisfactorily used; but it is unnecessary to discuss these in detail, as this treatment is very seldom effective, in preventing the attack of "Itten-O-Meiga", as has been already described.

## CHAPTER XII.

## CONCLUSION.

The control of "Itten-O-Meiga" may be effected in various ways, as has already been discussed above. It must be acknowledged that the effects and labour involved in the different treatments vary to a very large extent, and also that certain methods in practice will result in the diminution of the crop.

Doubtless, it is very difficult to choose among all the methods of control the one which is best, but this will probably be ascertainable from the different ways which have been already described. At first, we shall point out the most effective method of controlling the different stages of "Itten-O-Meiga", and then some of the best will be chosen in every stage.

### I. METHOD OF CONTROLLING THE MOTHS.

As a control of the moths there is no other method except capturing the moths or preventing their oviposition on the plant. There are two methods of effecting the fomer, viz.:— artificial destruction and application of the natural enemies; the latter nec-

essitates selection of paddy varieties and the use of certain preferable crops. The prevention method is absolutely impossible at the present time, therefore the capturing method only will serve as a control measure in the imago stage.

In the artificial destruction of the moths, the use of lantern-traps and of collecting nets is advocated, and it is obvious that the former of these is most successful in capturing the moths. In the application of the natural enemies, bats, spiders and birds are very effective in Formosa, it is probably impossible, however, to increase their ability for capturing the moths, or their numbers, by artificial protection, because they were naturalised a long time ago in the Island and a natural equilibrium is maintained between all their co-relatives. Turning our attention to other countries, it is entirely unknown what kinds of animals are the natural enemies of the moth.

From the above it is safe to conclude that the use of trap-lanterns will be the most successful control-measure in the imago stage ; of course, the natural enemies must be protected as much as possible.

## II. METHOD OF CONTROLLING THE EGGS.

The control measures which can be put in practice in the egg stage will be collection of egg-clusters, and the application of the natural enemies, although the application of poisons, or the power of natural external conditions, may be somewhat useful in preventing the hatching of the eggs.

The collection of the egg-masses in the rice bed is ineffective, and even in the field, it does not fulfil the desired results unless it is continuously put into practice from the young stage until after the shooting period.

In the application of the natural enemies, it has always been indicated by several entomologists, that a reliable protection of the natural enemies occurring in our countries is the first method of controlling the egg. But I am not afraid to say that any such



protection of the natural enemies cannot render them much more effective against the eggs than they are at the present time, for the reasons discussed in the preceding sections, and from the several experiments which have been already shown. In other countries two parasitic Hymenoptera are found which occur in our countries ; but at the present time the application of the natural enemies cannot be carried out by means of introducing other species which do not occur in our countries.

From the above it may be concluded that collection of the egg-masses in the field before the shooting period is the most effective method of control against the egg stage. Of course, protection of the natural enemies is a desirable matter.

## III. METHOD OF CONTROLLING THE LARVAE.

Controlling the larvae includes their destruction, protection against the injury which they caus, and preventing their pupation. Protection against their injury may be made by means of selecting paddy varieties and by the application of poisons ; but these do not give any effective results. As methods of preventing pupation, either the application of water or extreme temperature is the only method. These treatments are practically the same as those used in destroying the larvae. We will now turn to a discussion of the various destructive measures.

The treatments for destroying the larvae will be, naturally, different for newly-hatched or removing larvae and larvae living in the stems, and must be considered separately. In the former case, there is no treatment except either an application of poisons or destruction by hand, and these apparently give very poor results. In the latter case, the larvae must be destroyed by means of treatment of either the stumps or the injured stalks. The treatment of the injured stalks means, without doubt, the gathering of the "white ears" and withered stems ; a small percentage of larvae are destroyed

in this way but a large percentage escape quite safe, being in non-withered stems. The percentage of such larvae is, on an average, about 73, according to investigations made upon 300 paddy stools (about 13589 stems). Indeed, only 27 pet cent of the larvae living in a field will be destroyed, when all the "white ears" and withered stalks are gathered. It may be considered that the larvae will be destroyed little more by this control measure than the natural enemies, although this treatment can be satisfactorily put into practice.

From both the above and the statements made in Chapter XI, it will be seen that the gathering of "white ears" and withered stems is an undesirable method of control in the larval stage. Owing to the habits of the larvae, treatment of the paddy stubble during the winter time will destroy all the hibernating larvae, if it can be carefully put into practice.

There are many methods to absolutely destroy the hibernating larvae, and these must be chosen according to the condition of the field.

(1) In a dry field, which is not suitable for being ploughed, the stumps must be dug out and then buried or burned. If the field is composed of dry, hard clay, they must be pulled up instead of dug out. In this case, a number of stumps remain in the soil, therefore they must be covered with mud or soft soil to accomplish the desired results.

(2) In a moist field the stumps must be ploughed into the soil, and the still exposed ones must be gathered in one spot and burned or buried.

(3) In a field which can be flooded, the stumps must be submerged and the field must be ploughed, in order that the amount of the next crop shall not be decreased.

The hibernating larvae can be satisfactorily destroyed by means of the above three treatments, and these methods are most effective against the larval stage.



Lastly, we must discuss the natural enemies. There are many enemies, as has already been described, but their capability of attacking the larvae is rather slight, and also, although they can be protected to some extent, in order to increase them, it will probably be impossible to control the larvae more than is done at the present time, for the reason already discussed.

Certainly, I do not hesitate to say that the treatment of the paddy stubble during the winter time is the most effective means of controlling the larvae.

## IV. METHOD OF CONTROLLING THE PUPAE.

No treatment will be discussed as a special control measure in the pupal stage, owing to the habits. Some methods used against the larval stage will serve to destroy the pupae; that is, treatment of the paddy stubble during the winter time, and gathering the "white ears" and withered stalks. It may be considered that their effects in destroying the pupae are nearly the same as in the larval stage. At the present time it is probable that an application of natural enemies cannot be put into practice.

## V. CONCLUSION.

In the above, a most effective control measure has been chosen for each of the different stages of "Itten-O-Meiga", separately; that is, in the imago stage, an application of trap-lanterns; in the egg-stage, collection of egg-masses befor the shooting of the paddy; and in the larval and pupal stages, several treatments of paddy stubble during the winter time. These are, doutless, most effective respectively in the different stages of "Itten-O-Meiga", as control measures, but it must be doubted whether all of these methods are really effective in controlling "Itten-O-Meiga", through all the stages.

Now the purpose of controlling an injurious insect must be either to directly increase the amount of the crops, or to decrease the

emergence of the next generation. In the above three methods, the destruction of the moths and egg-masses rather belongs to the former class, and the treatment of paddy stubble means the latter.

Theoretically, if a moth is destroyed an effect must appear, because the eggs (after deducting a certain number which will be destroyed by natural enemies) which would be deposited by the moth would hatch, and the larvae would injure a certain number of plants. However, nobody has yet recognised the effect, notwithstanding that this method has been annually put into practice during the last few years, at least, and even more than ten years ago. Really, it is obvious that destruction of the moths is inferior to the collection of egg-masses, in direct effect appearing in the yields.

This is probably due to the fact that the moths emerging naturally cannot be entirely destroyed, since they are not gathered in much greater numbers than those destroyed by natural enemies; also this method has not been put into practice uniformly throughout our country. I believe that this method is not certainly effective when farmers are allowed to do as they please, individually; and also that it is not superior to the other two methods, although it can be uniformly put in practice throughout a country.

In practice, collecting the egg-masses in the field before the shooting of the paddy is obviously effective in individual fields, as has been already discussed. However, it will be ineffective when there is a probability that the number of eggs collected is not greater than those destroyed by natural enemies and other agents. But such a case will be exceptional, because there is very little likelihood that all the eggs in an egg-mass would be destroyed by natural enemies or an unknown agency, excepting in cases where the egg-masses are attacked by a predaceous enemy, and up to the present time there are very few of these, and they very rarely destroy all the eggs in a cluster. Undoubtedly, the collection will be directly effective on the yields of paddy, and the effect will be proportional to the number



of collected egg-masses, if practised before the shooting of the paddy plant, and not when it is very young.

The last method is the treatment of paddy stubble during the winter time, before the emergence of the moth. Theoretically this will be the most effective means of checking the annual emergence of "Itten-O-Meiga", but it is often ineffective in practice. This is chiefly due to the fact that the hibernating larvae (or pupae) are destroyed by natural enemies and by certain external conditions, to a large percentage, over ninety according to my investigations in Formosa, and over fifty in Japan, and that the moths which emerge from them can emigrate over four miles. Really, this control measure should be very throughly put in practice throughout the whole country; and if this was done, other control measures would probably not be necessary, during many years.

From the above discussion, it may be concluded that there are only two effective methods of control.

1. For the purpose of direct control, field collection of the egg-masses must be practised before paddy shooting, repeating the collection at every crop, in each year.
2. To check the actual emergence during winter time before the emergence of the moths burning of the paddy stumps must be applied in a dried field, burying by means of ploughing in a moist field, and submerging in a field which can be flooded. These treatments should not be left to the farmers entirely, but should certainly be put in practice throughout localities bounded by mountains, or water, or uncultivated land, for at least five miles around, and under strict supervision.

Lastly, the natural enemies must be discussed. Introducing the natural enemies from other countries will be very necessary to check the increase of "Itten-O-Meiga". The enemies must be such as do not occur in our countries, and the proportion which they destroy of "Itten-O-Meiga" in the other countries must be much more than that

of our natural enemies. If such an enemy is found, its introduction may serve to check the present increase of "Itten-O-Meiga". According to the investigations of many students, in other countries where the species occurs the paddy plant is annually injured by it almost as severely as in our countries, or even more so. From this fact, it will be suggested that there are probably no natural enemies (nor other agencies), which destroy "Itten-O-Meiga" any more than in our countries.

But, in Ceylon, this pest is not known to attack the paddy plant. Probably, there are here effective natural enemies, or else there may be certain plants which "Itten-O-Meiga" prefers to paddy, or possibly external conditions are not suitable to its increase. If the most effective of these conditions be applied in our countries, probably it might serve to decrease the injury to its present level in Ceylon.

To sum up; as a method of control, the treatment of paddy stubble, satisfactorily put into practice, comes first; but, if this cannot be done, collection of the egg-clusters must be practised before the shooting of the paddy. And at the same time, a detailed study of "Itten-O-Meiga" in Ceylon must be made, for the purpose of discovering a natural control for the insect.

The End.



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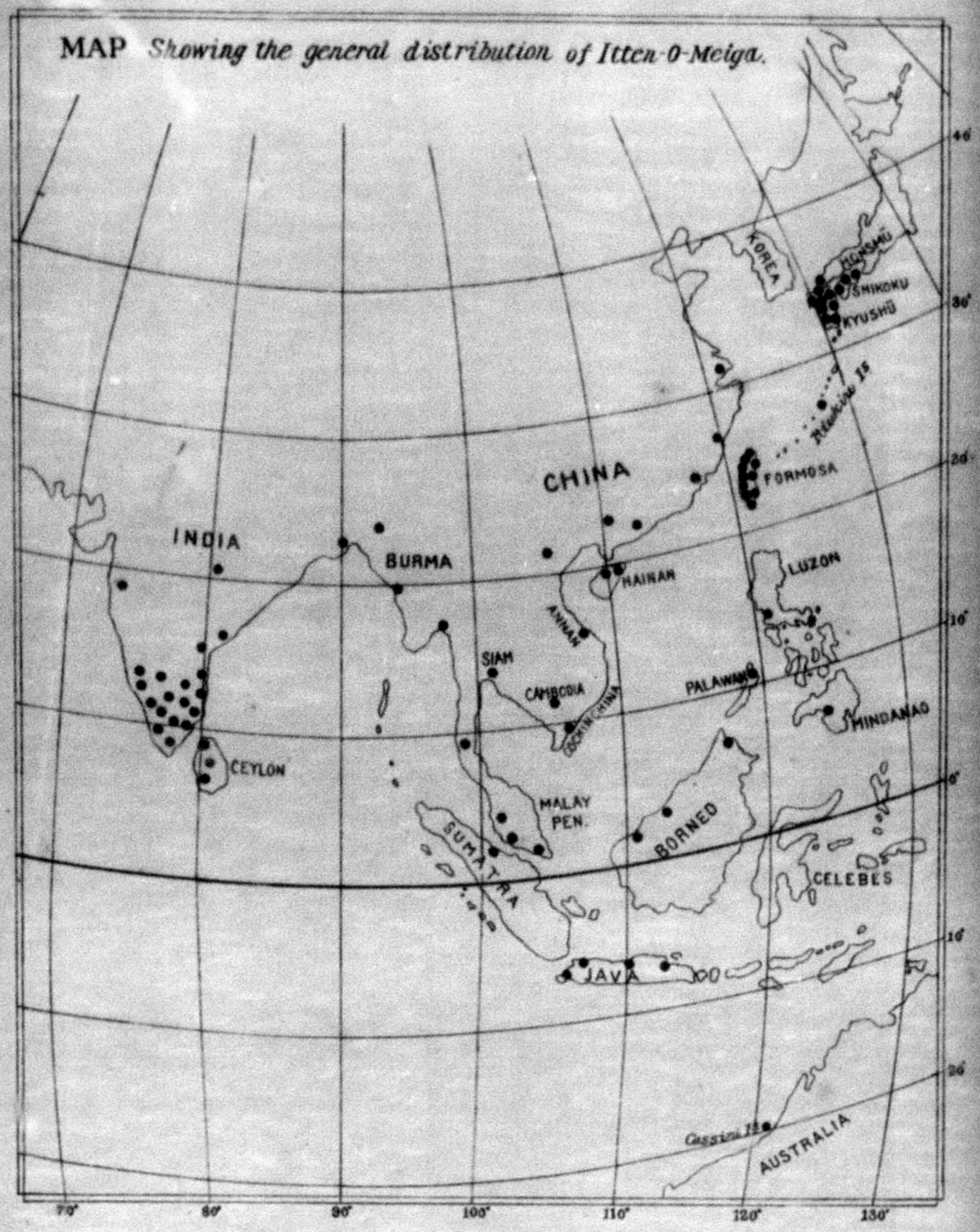




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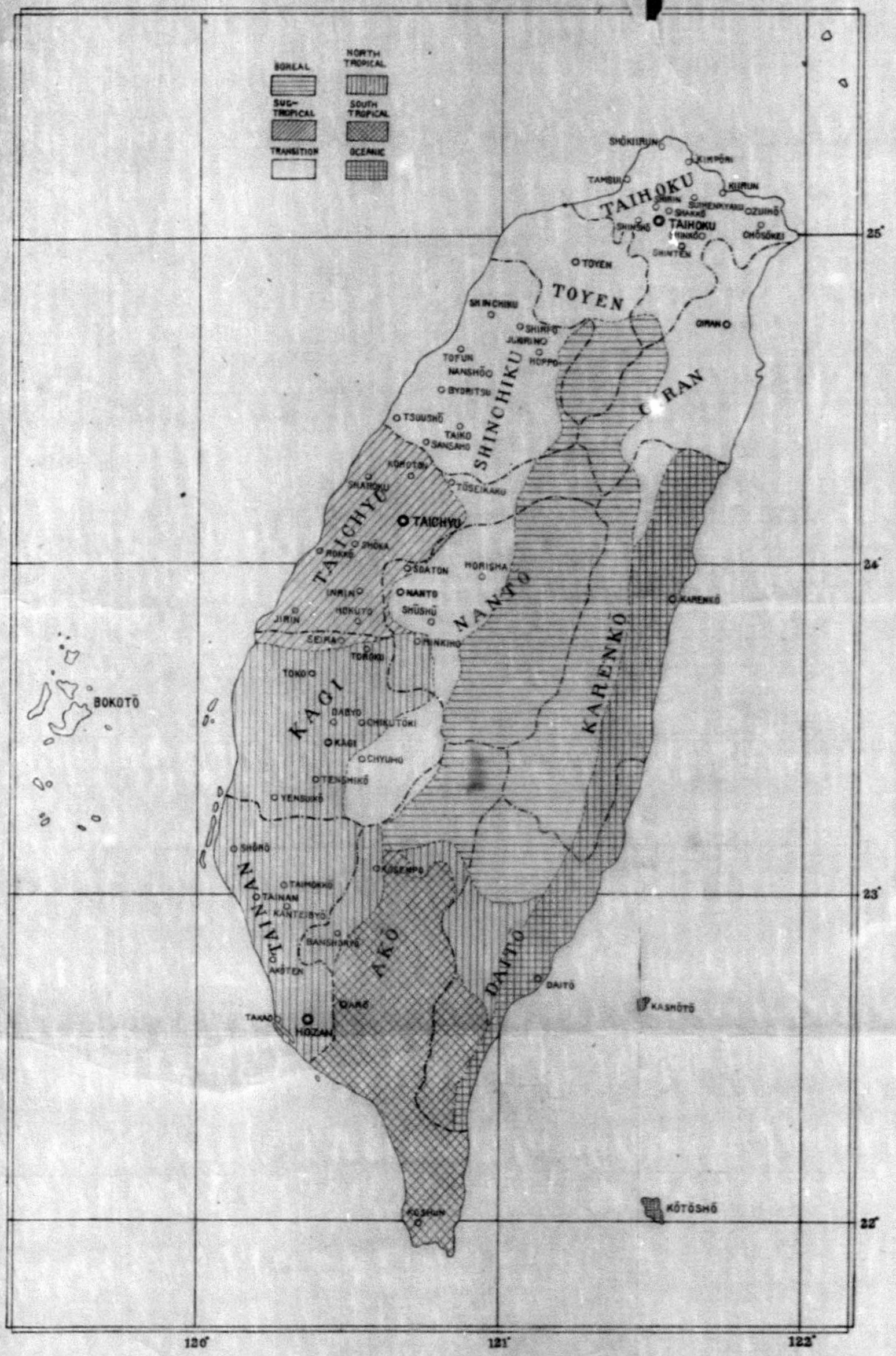
Plate I. *Probable Life Areas of Insects of* [redacted]*nosa.*



## PLATE IV.

**Fig. 1.** Dorsal surface of egg-mass of *Schoenobius incertellus*, with covering hairs removed (4 times the natural size in diameter.)

**Fig. 2.** The same. (4 times the natural size in diameter.)

**Fig. 3.** Ventral surface of egg-mass of *Schoenobius incertellus*. (4 times the natural size in diameter.)

**Fig. 4.** The same. ( " " " " )

**Fig. 5.** View of longitudinal section of centre of egg-mass. (4 times the natural size in diameter.)
(a) Covering hairs (b) Egg.

**Fig. 6.** View of outer surface of paddy stem, showing entrance hole bored by three of the newly-hatched larvae. (5 times the natural size in diameter.)
(a) Entrance hole. (b) Tunnel bored by larva in tissue of stem, viewed from outer surface of stem. (c) Fibres of the tissue, as it appeared during the boring (d) Excrement of the larva.

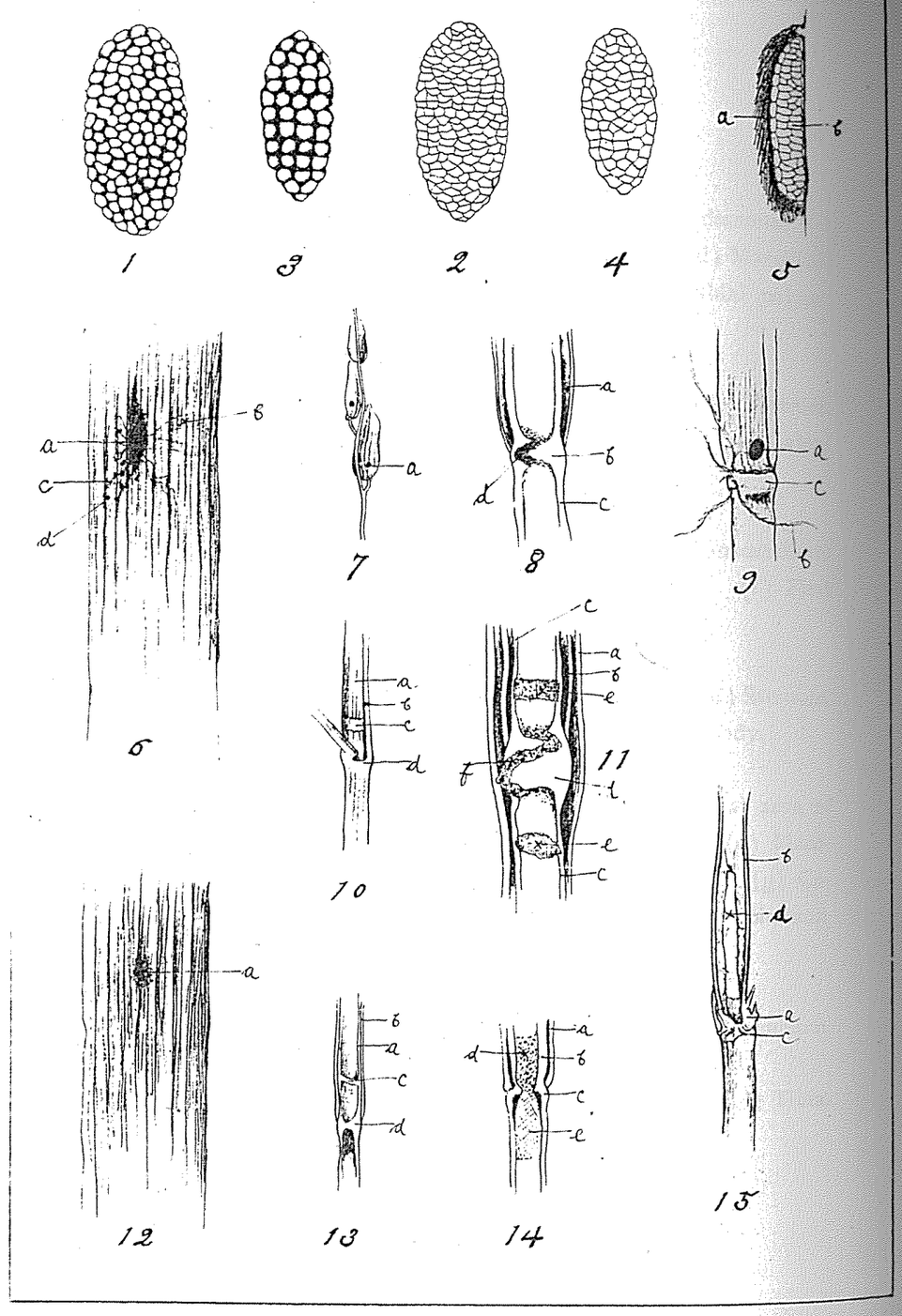
**Fig. 7.** Entrance hole (a) bored by newly-hatched larva in unripened rice, in the rolled-up leaves, just before the shooting period.
(1.8 times the natural size in diameter.)

**Fig. 8.** View of injured node of paddy stem in longitudinal section. (enlarged.) (a) Sheath. (b) Node. (c) Wall of stem. (d) Tunnel bored by a larva.

**Fig. 9.** Exit-hole of moth,—view of outer surface of stem. (natural size.)
(a) Emerging hole. (b) Newly-developed roots owing to the injury. (c) Node of paddy stem.

**Fig. 10.** One of the injured stems. (natural size.)
(a) Stalk of ear. (b) Sheath. (d) First node.

Plate IV




(c) View of injured portion of ear-stalk where it was absolutely cut off, and spun over by the larva.

**Fig. 11.** View of longitudinal section of injured stem (enlarged.) (a)(b) Sheath of leaf. (c) Wall of stem. (d) Node (e) Injured inner surface of stem. (f) Larval burrow in the node.

**Fig. 12.** View of outer surface of injured stem, an entrance-hole (a) bored by a single larva.
(5 times the natural size in diameter.)

**Fig. 13.** View of longitudinal section of stem injured by a single larva, before it had bored through the first node of paddy. (natural size.)
(a) Wall of stalk of ear. (b) Sheath. (c) View of injured portion of inner wall of ear-stalk. (d) Node.

**Fig .14.** One of the protecting cocoons spun by a larva just before moulting. (Longitudinal section—enlarged.)
(a) Sheath of leaf. (b) Wall of stem. (c) Node of stem. (d) Excrement of larva. (e) Upper end of cocoon.

**Fig. 15.** One of the protecting cocoons spun by a larva of stage IV, in [illegible] stem. (natural size.)
(a) Sh[illegible] of leaf. (b) Longitudinal section of stem. (c) Node of stem. (d) Cocoon protecting against submergence in which the larva lives head downwards.

## PLATE V.

*Imago of Schoenobius Incertellus.*

**Fig. 1.** Frontal view of head.
(54 times the natural size in diameter.)
(a) Eye. (b) Clypeus. (c) Labrum. (d) Mandible. (e) Epipharynx. (f) Rostrum. (g) Labial palpus. (h) Maxillary palpus. (i) Antenna.

**Fig. 2.** Front ventral view of head. (enlarged.)
(a) Eye. (b) Clypeus. (c) Labrum. (d) Rostrum. (e) Epipharynx. (g) Maxillary palpus. (h) Labial palpus.

**Fig. 3.** Dorsal view of thorax. (enlarged.)
(a) Mesoscutum. (b) Tegula. (c) Mesoscutellum. (d) Metascutum. (e) Metascutellum. (f) First abdominal segment.

**Fig. 4.** Front ventral view of prothorax. (enlarged.)
(a) Patagia. (b) Pleuron. (c) Notum. (d) Sternum. (e) Coxa of anterior leg. (f) Cavity of body.

**Fig. 5.** Lateral view of thorax. (enlarged.)
(a) Tegula. (b) Pro-epimeron. (c) Basal area of anterior wing. (d) Meso-episternum. (e) Meso-epimeron. (f) Basal area of posterior wing. (g) Coxae. (h) Meta-episternum. (i) Meta-epimeron. (j) First segment of abdomen.

**Fig. 6.** Left wings showing venation. (enlarged.)
(a) Anterior wing. (b) Posterior wing. (c) Frenulum.

**Fig. 7.** Fore leg. (enlarged.)
(a) Coxa. (b) Trochanter. (c) Femora. (d) Tibia. (e) Tarsus.

**Fig. 8.** Mid leg. (enlarged.)

**Fig. 9.** Hind leg. (enlarged.)

Plate V

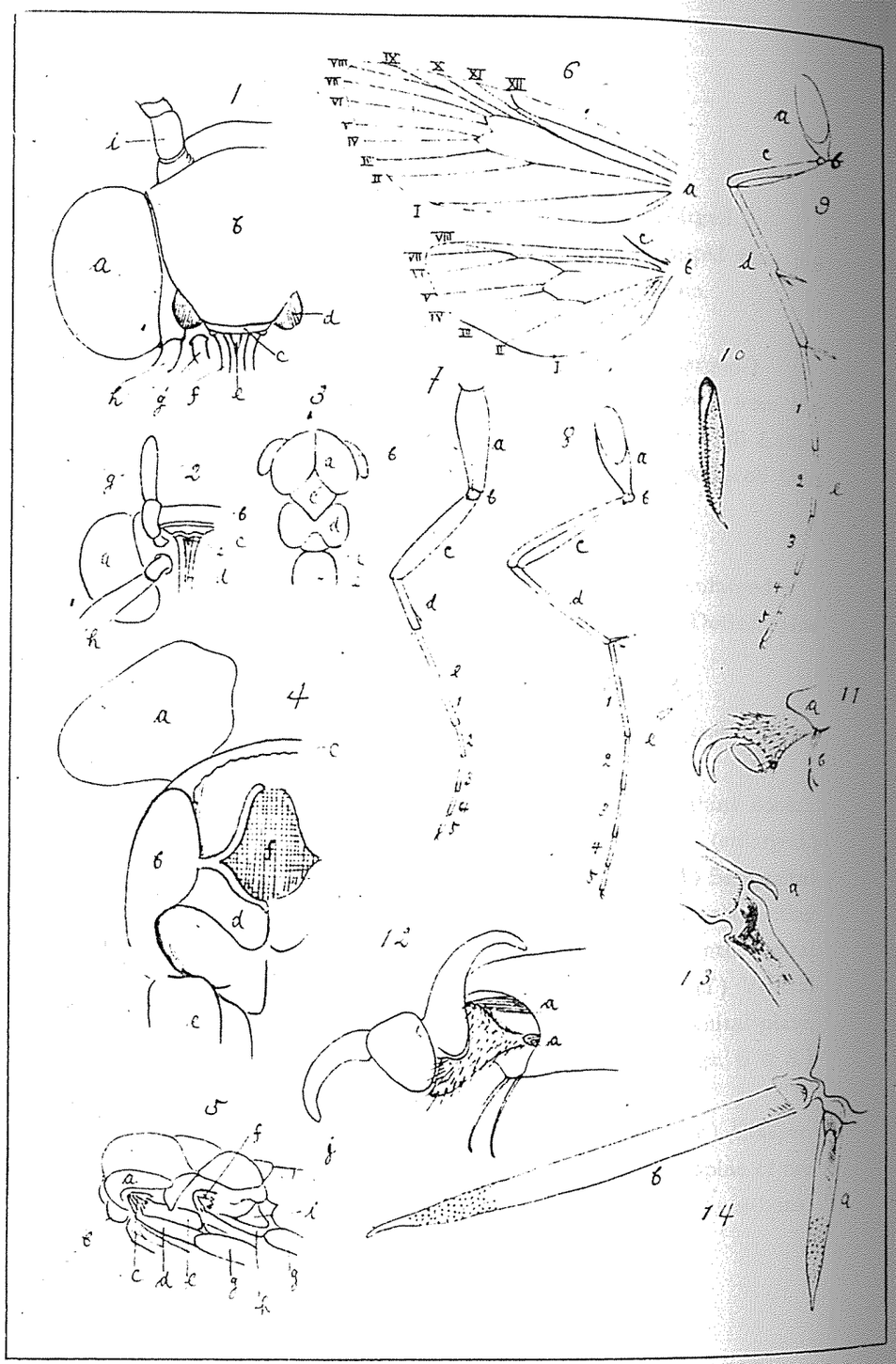


**Fig. 10.** Spur of fore tibia. (50 times the natural size in diameter.)

**Fig. 11.** Claws at end of tarsus. (enlarged.)
(a) Fifth joint of tarsus. (b) Sensory hairs.

**Fig. 12.** The same. (enlarged.)
(a) Claw muscles.

**Fig. 13.** Joint of tarsus. (enlarged.)
(a) Dorsal.

**Fig. 14.** Spurs of mid tibia. (enlarged.)
(a) Outer spur. (b) Inner spur.

## PLATE VI.

*Imago of Schoenobius incertellus.*

**Fig. 1.** Dorsal view of the head of the male. (enlarged.)
(a) Maxillary palpi. (b) Hairs produced from the basal area of the clypeus. (c) Antenna.

**Fig. 2.** The same of the female. (enlarged.)

**Fig. 3.** Lateral view of the head of the male. (enlarged.)
(a) Maxillary palpi. (b) Hairs produced from the basal area of the clypeus. (c) Antenna. (d) Labial palpus. (e) Rostrum. (f) Hairs produced from the tegula.

**Fig. 4.** The same of the female. (enlarged.)

**Fig. 5.** Dorsal view of the abdomen of the male. (enlarged.)
(a) Suranal plate. (b) Clasper. (c) Dorsal spine the third hook (uncus).

**Fig. 6.** [illegible]l view of the same. (enlarged.)
(a) Large brush at the base of the subgenital plate.
(b) Subanal plate (modification of cerci).
(c) Clasper. (d) Ventral spine of the third hook.

**Fig. 7.** Ventral view of the anal portion of the male. (enlarged.)
(a) Small brush on the subgenital plate. (b) Subgenital plate. (c) Subanal plate. (d) Membrane connecting the subanal plates (modification of the seventh ventral segment of the abdomen.) (e) Clasper. (f) Ventral spine of the third hook. (h) Base of the subgenital plate, where it bears the large brush. ("a" of figs. 6 & 8.)

**Fig. 8.** Lateral view of the same. (enlarged.)
(a) Large brush. (b) Subanal plate. (c) Clasper. (d) Suranal plate. (e) Base of the dorsal spine of the third hook. (f) Membranous connection of the subanal plates.

**Fig. 9.** Ventral view of the same showing the covering scales. (enlarged.)
(a) Apex of the ventral spine of the third hook.
(b) Clasper.

**Fig. 10.** Dorsal view of the same showing covering scales. (enlarged.)
(a) Apex of the dorsal spine of the third hook.
(b) Clasper.

**Fig. 11.** Ventral view of the abdomen of the female. (enlarged.)
(a) Subgenital plate. (b) Suranal plate.
(c) Apex of the genital organ. (d) Sternum.

**Fig. 12.** Dorsal view of the same. (enlarged.)
(a) Metascutellum. (b) Suranal plate. (c) Apex of the genital organ. (d) Anal tuft. (e) Inner anal tuft.

**Fig. 13.** Lateral view of the anal portion of the female. (enlarged.)
(a) Suranal plate. (b) Subgenital plate. (c) Apex of the genital organ. (d) Seventh dorsal segment of the abdomen. (e) Sixth ventral segment of the abdomen. (f) Sixth lateral segment of the abdomen.

**Fig. 14.** Ventral view of the same. (enlarged.)
(a) Suranal plate. (b) Subgenital plate.
(c) Apex of the genital organ.

**Fig. 15.** Ventral view of the genital organ of the female. (38 times the natural size in diameter.)

**Fig. 16.** Ventral view of the anal portion of the female, showing the anal tufts. (enlarged.)
(a) Apex of the genital organ. (b) Tuft on the sixth ventral segment of the abdomen. (c) Tuft on the sixth lateral segment of the abdomen. (d) Anal tuft on the seventh dorsal segment of the abdomen. (e) Inner anal tuft consisting of soft hairs.

**Fig. 17.** Dorsal view of the same, showing the outer anal tuft (a). (enlarged.)

## Plate VI

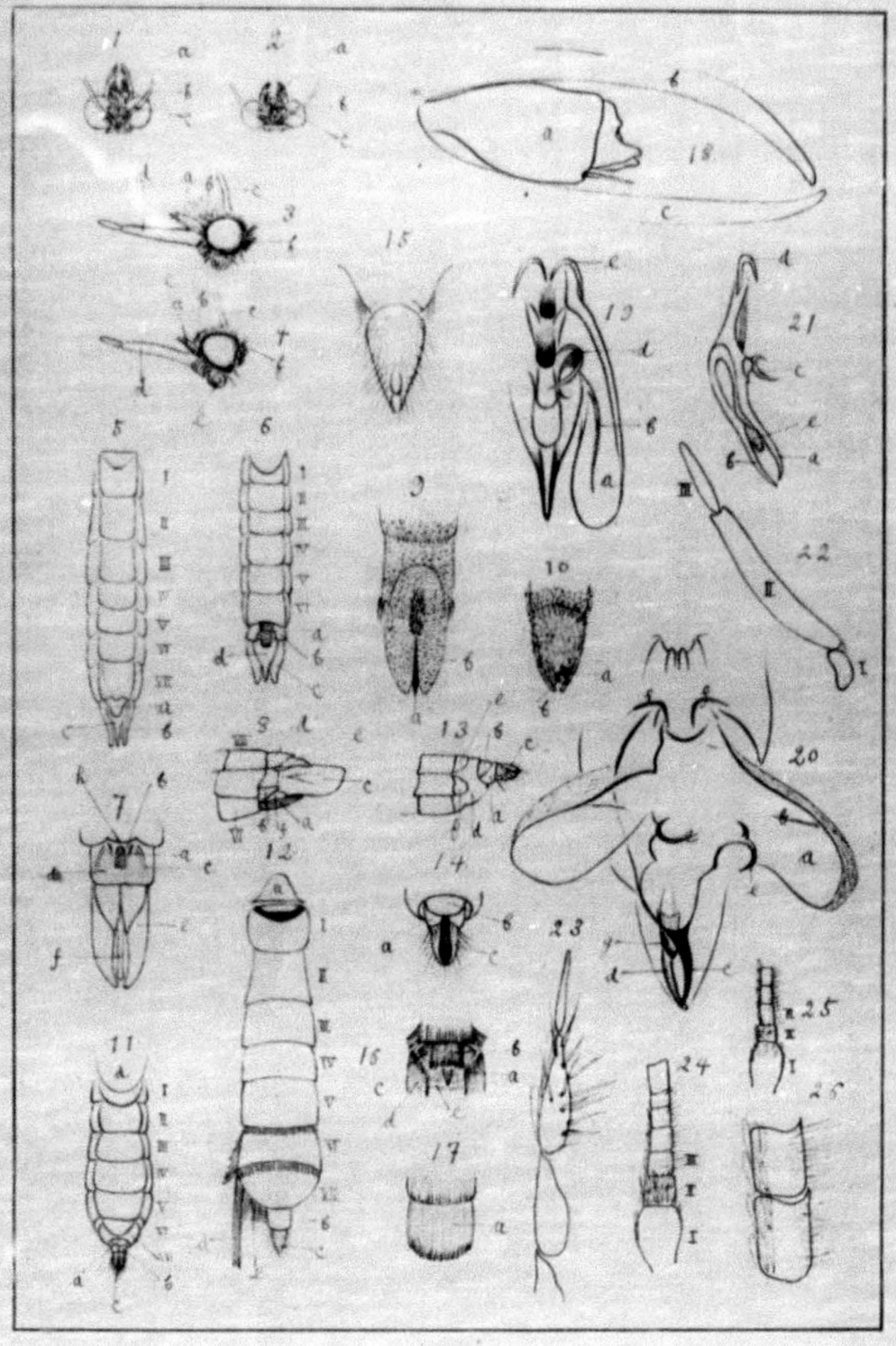


Fig. 18. Lateral view of the genital organ of the male. (enlarged.)
(a) Penis. (b) Ventral spine of the third hook.
(c) Dorsal spine of the third hook.

Fig. 19. Ventral view of the same. (enlarged.)
(a) Clasper. (b) Chitinous fold on the inner surface of the clasper. (c) Apex of the third hook. (d) Second hook. (e) First hook.

Fig. 20. Ventral view of the same, with the claspers spread laterally. (enlarged.)
(a) Clasper. (b) Chitinous fold on the inner surface of the clasper. (c) Ventral spine of the third hook. (d) Dorsal spine of the third hook. (e) Second hook. (f) First hook. (g) Penis.

Fig. 21. Lateral view of the clasper. (enlarged.)
(a) Ventral spine of the third hook. (b) Dorsal spine of the third hook. (c) Second hook. (d) First hook. (e) Penis.

Fig. 22. Labial palpi. (27 times the natural size in diameter.)

Fig. 23. Apical portion of the antennae. (enlarged.)

Fig. 24. Basal portion of the antennae of the female. (enlarged.)

Fig. 25. The same of the male. (enlarged.)

Fig. 26. Middle joints of the antennae. (enlarged.)

## PLATE VII.

*Schoenobius incertellus*, Wlk.

**Fig. 1.** Dorsal view of the pupa of the female.
(4 times the natural size in diameter.)

**Fgi. 2.** Ventral view of the same.
(4 times the natural size in diameter.)

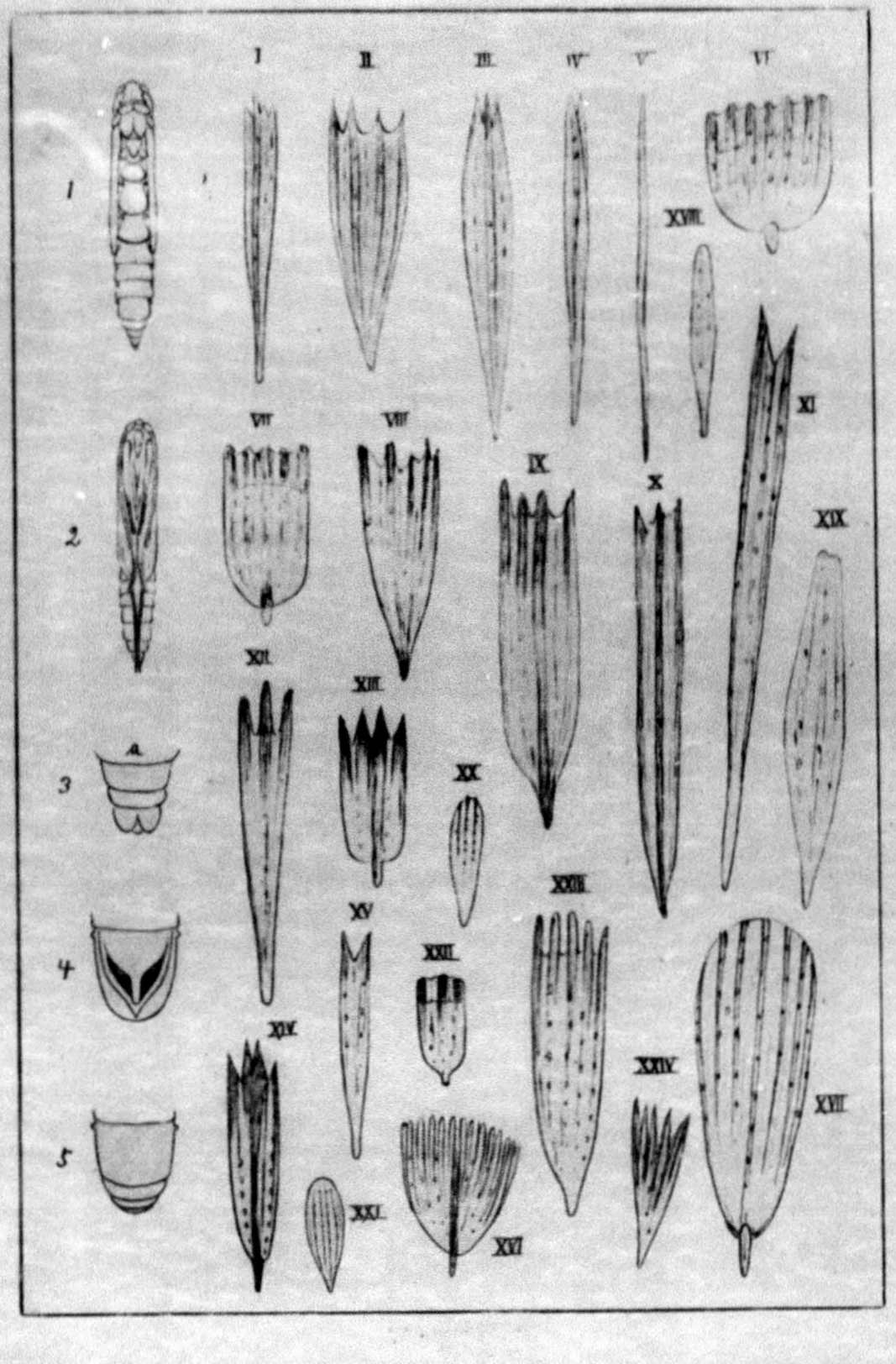
**Fig. 3.** Ventral view of the anal end of the male pupa. (enlarged.)
(a) Seventh ventral segment of the abdomen.

**Fig. 4.** Ventral view of the anal end of the female pupa.
(enlarged.)

**Fig. 5.** Dorsal view of the same. (enlarged.)

**Figs.** Various types of the scales on the whole body of the imago.
(300 times the natural size.)

Plate VII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XIV
XV
XXII
XXIII
XXIV
XVII
5
XXI
XVI

## PLATE VIII.

*Schoenobius incertellus*, Wlk.

**Fig. 1.** Pupal cocoon formed in paddy stem. (natural size.)
(a) Cocoon. (b) Emergence hole. (c) Dust gnawed by the larva in boring through the stem wall.
(d) Connecting membrane between the stem wall and pupa. (e) Lower end.

**Fig. 2.** The same. (natural size.)
(a) Cocoon. (b) Emergence hole, with remains of epidermal skin of the stem. (In this case the epidermal skin of the area almost always withers naturally, and the moth is able to emerge from the stem.)
(c) Emerging-way formed by threads between the emergence hole and the cocoon. (d) Connecting membrane between the stem wall and pupa.

**Fig. 3.** Temporary cocoon formed by the larva in stage IV at the moulting time. (natural size.)
(a) Old skin of the larva. (b) Temporary cocoon.
(c) The situation of the head of the newly-moulted larva in stage V.

**Fig. 4.** Temporary house, formed of a paddy leaf, constructed by the larva when removing from one stem to another. (enlarged.)

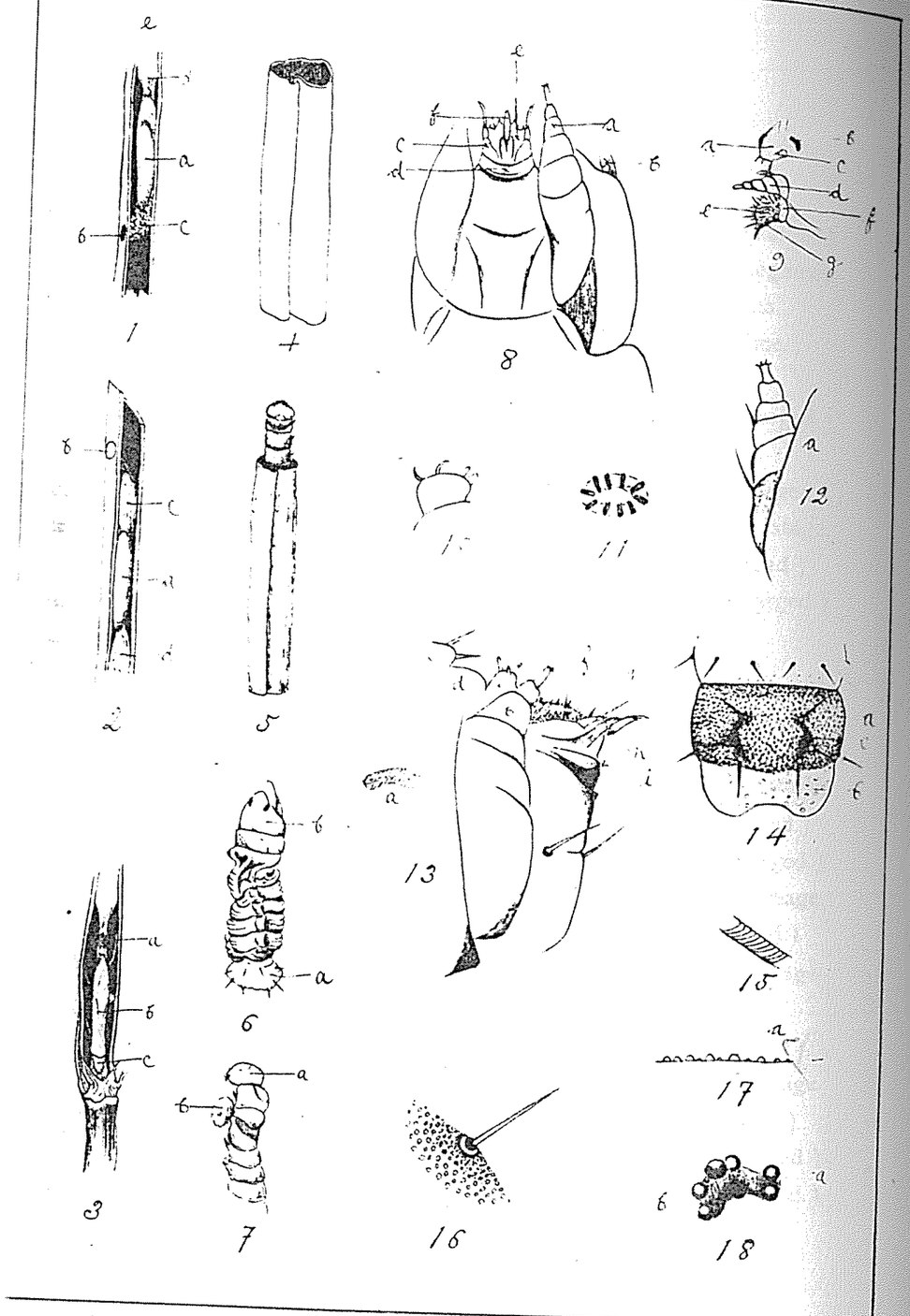
**Fig. 5.** Larva living in temporary house. (enlarged.)

**Fig. 6.** Old skin of the larva, left after moulting. (enlarged.)
(a) Head. (b) Anal segment.

**Fig. 7.** Beginning of a moult. (enlarged.)
(a) Head. (b) Old skin of the head.

**Fig. 8.** Ventral view of the head of the larva in stage I. (enlarged.)
(a) Maxillary palpus. (b) Antenna. (c) Labial palpus. (d) Mentum. (e) Labium. (f) Process of

Plate VIII



the labium.

**Fig. 9.** Lateral view of the apex of the head of the same. (enlarged.)
(a) Labrum. (b) Eye spot. (c) Antenna.
(d) Maxillary palpus. (e) Labium. (f) Mentum.
(g) Process of the labium.

**Fig. 10.** Dorsal view of the left maxilla of the same. (enlarged.)

**Fig. 11.** Ventral view of the apex of the proleg of the same, showing the arrangement of the hooks. (enlarged.)

**Fig. 12.** Outside view of the maxillary palpus of the same.
(a) Lateral surface of the head. (enlarged.)

**Fig. 13.** Lateral view of the head of the larva in stage II. (enlarged.)
(a) Eye spot. (b) Maxillary palpus.
(c) Labrum. (d) Mandible.
(e) Maxilla. (f) Labium.
(g) Labial palpus. (h) Process of the labium.
(i) Mentum.

**Fig. 14.** Dorsal view of the anal segment of the larva in stage I. (enlarged.)
(a) Anal segment. (b) Anal leg.
(c) Chitinous plate.

**Fig. 15.** Tracheae of the larva in stag II. (enlarged.)

**Fig. 16.** Hair on dorsum of the same. (enlarged.)

**Fig. 17.** Cross section of the epidermis of the same. (enlarged.)
(a) Chitinous granules which are closely scattered on the whole surface of the body.

**Fig. 18.** Eye spot of the same. (enlarged.)
(a) Ocellus. (b) Coloured area.

## PLATE IX.

*Larva of Schoenobius incertellus.*

**Fig. 1.** Dorsal view of the head and thorax in stage III. (enlarged.)
(a) Head. (b) First segment. (c) Second segment.
(d) Third segment. (e) & (f) Indistinct spots.
(g) Chitinous plate. (h) Indistinct central line.
(i) Sutural membrane.

**Fig. 2.** Dorsal view of the anal area in the same stage. (enlarged.)
(a) Anal leg. (b) Anal segment.

**Fig. 3.** Ventral view of the head in the same stage. (enlarged.)

**Fig. 4.** Lateral view of the head and thorax in the same stage. (enlarged.)

**Fig. 5.** Dorsal view of the head in the same stage. (enlarged.)
(a) Mandible. (b) Labrum.
(c) Antenna. (d) Clypeus.

**Fig. 6.** Dorsal view of the anal segment in the same stage.
(a) Anal leg. (enlarged.)

**Fig. 7.** Ventral view of the apex of the proleg in the same stage, showing the arrangement of the hooks. (enlarged.)

**Fig. 8.** Outer side of the antenna in the same stage. (enlarged.)

**Fig. 9.** Dorsal lateral view of the left mandible in the same stage. (enlarged.)

**Fig. 10.** Dorsal view of the abdominal segment in the same stage.
(a) Second abdominal segment. (enlarged.)
(b) Transverse sulcus. (c) Central line.

**Fig. 11.** Outer side of the maxillary palpus in the same stage. (enlarged.)

**Fig. 12.** Ventral view of the labrum in the same stage. (enlarged.)

**Fig. 13.** Outer side of the maxilla in the same stage. (enlarged.)

**Fig. 14.** Outer side of the leg in the same stage. (enlarged.)

**Fig. 15.** Claw of the same. (enlarged.)

## Plate IX

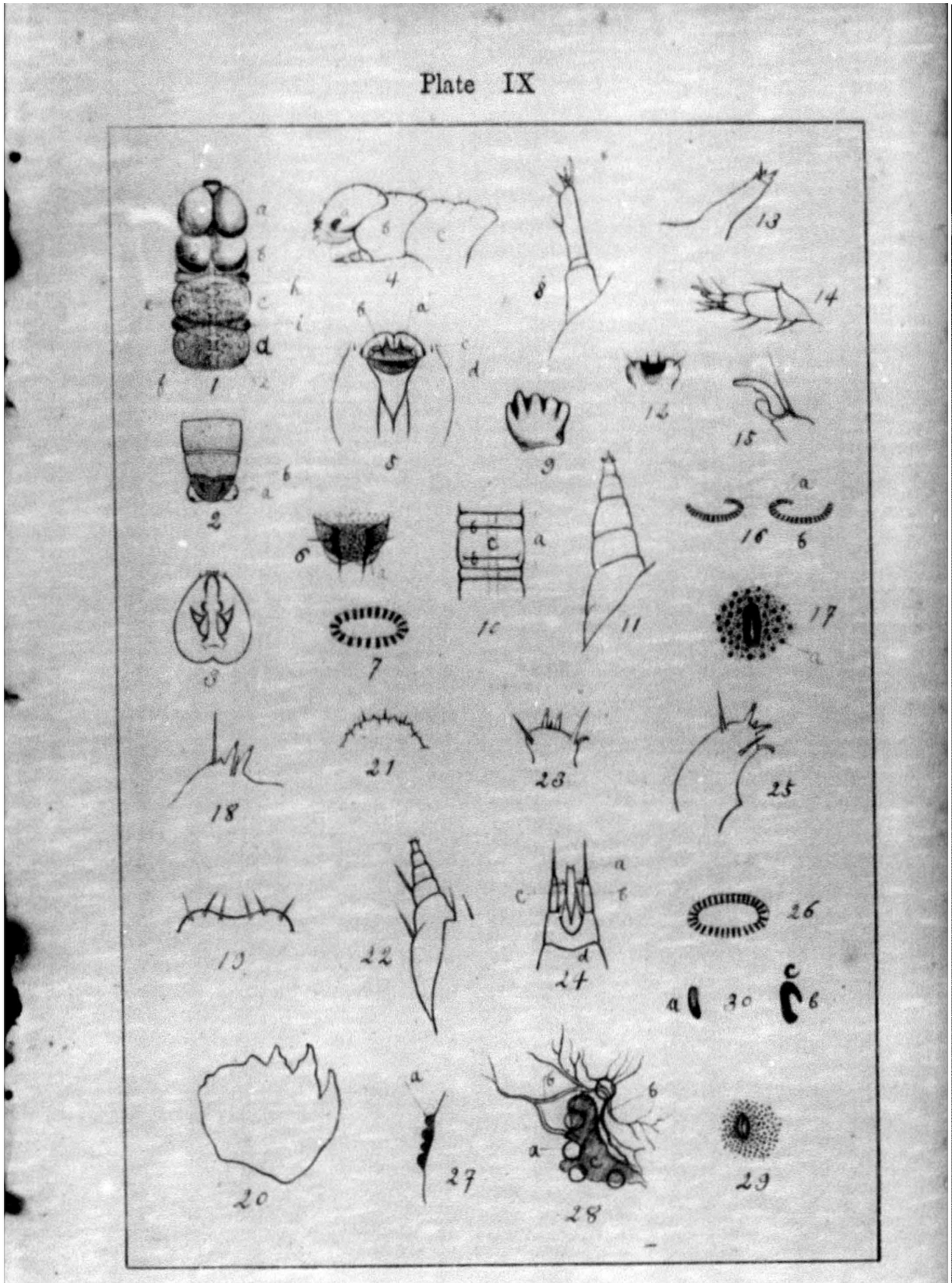


Fig. 16. Ventral view of the apex of the anal leg, showing the arrangement of the hooks. (enlarged.)
(a) Front. (b) Hind.

Fig. 17. Spiracle in the same stage. (enlarged.)
(a) Chitinous granule.

Fig. 18. Dorsal view of the left maxilla in stage IV. (enlarged.)

Fig. 19. Dorsal view of the labrum in the same stage. (enlarged.)

Fig. 20. Outer side of the right mandible in the same stage. (enlarged.)

Fig. 21. Dorsal view of the labium in the same stage. (enlarged.)

Fig. 22. Lateral view of the outer side of the maxillary palpus in the same stage. (enlarged.)

Fig. 23. Lateral view of the outer side of the left maxilla in the same stage. (enlarged.)

Fig. 24. Ventral view of the mid area of the head in the same stage. (enlarged.)
(a) Process of the labium. (b) Labial palpus.
(c) Labium. (d) Pharynx.

Fig. 25. Lateral view of the outer side of the left maxilla in the same stage. (enlarged.)

Fig. 26. Ventral view of the apex of the proleg, showing the arrangement of the hooks, in the same stage. (enlarged.)

Fig. 27. Lateral view of the eye spot in the same stage.
(a) Ocellus. (enlarged.)

Fig. 28. Dorsal view of the eye spot, showing the nervous system, in the same stage. (enlarged.)
(a) Ocellus. (b) Nerves. (c). Coloured area.

Fig. 29. Spiracle in the same stage. (enlarged.)

Fig. 30. Hook of the proleg in the same stage. (enlarged.)
(a) Ventral view. (b) Lateral view. (c) Inner side.

## PLATE X.

*Larva of Schoenobius incertellus in stage V.*

**Fig. 1.** Lateral view of the leg. (enlarged.)
(a) First joint. (b) Second joint. (c) Third joint.
(d) Fourth joint. (e) Claw. (f) Setae.

**Fig. 2.** Lateral view of the proleg. (enlarged.)
(a) Lateral side of the abdomen. (b) Proleg.
(c) Hook.

**Fig. 3.** Dorsal view of the antenna. (enlarged.)
(a) First joint. (b) Second joint. (c) Outer side.
(d) Inner side. (e) Sensory setae. (f) Seta.

**Fig. 4.** Dorsal view of the maxillary palpus. (enlarged.)
(a) Third joint. (b) Fourth joint. (c) Fifth joint.
(d) Outer side. (e) Inner side. (f) Sensory granules.

**Fig. 5.** Lateral view of the labial palpus. (enlarged.)
(a) First joint. (b) Second joint. (c) Third joint.
(d) Dorsal side. (e) Sensory hairs.

**Fig. 6.** Lateral view of the process of the labium. (enlarged.)
(a) Dorsal side. (b) Ventral side.
(c) Appendage at the apex.

**Fig. 7.** Ventral view of the right maxilla. (enlarged.)
(a) Maxilla. (b) Maxillary palpus. (c) Upper side.
(f) Outer side. (g) Sensory setae.

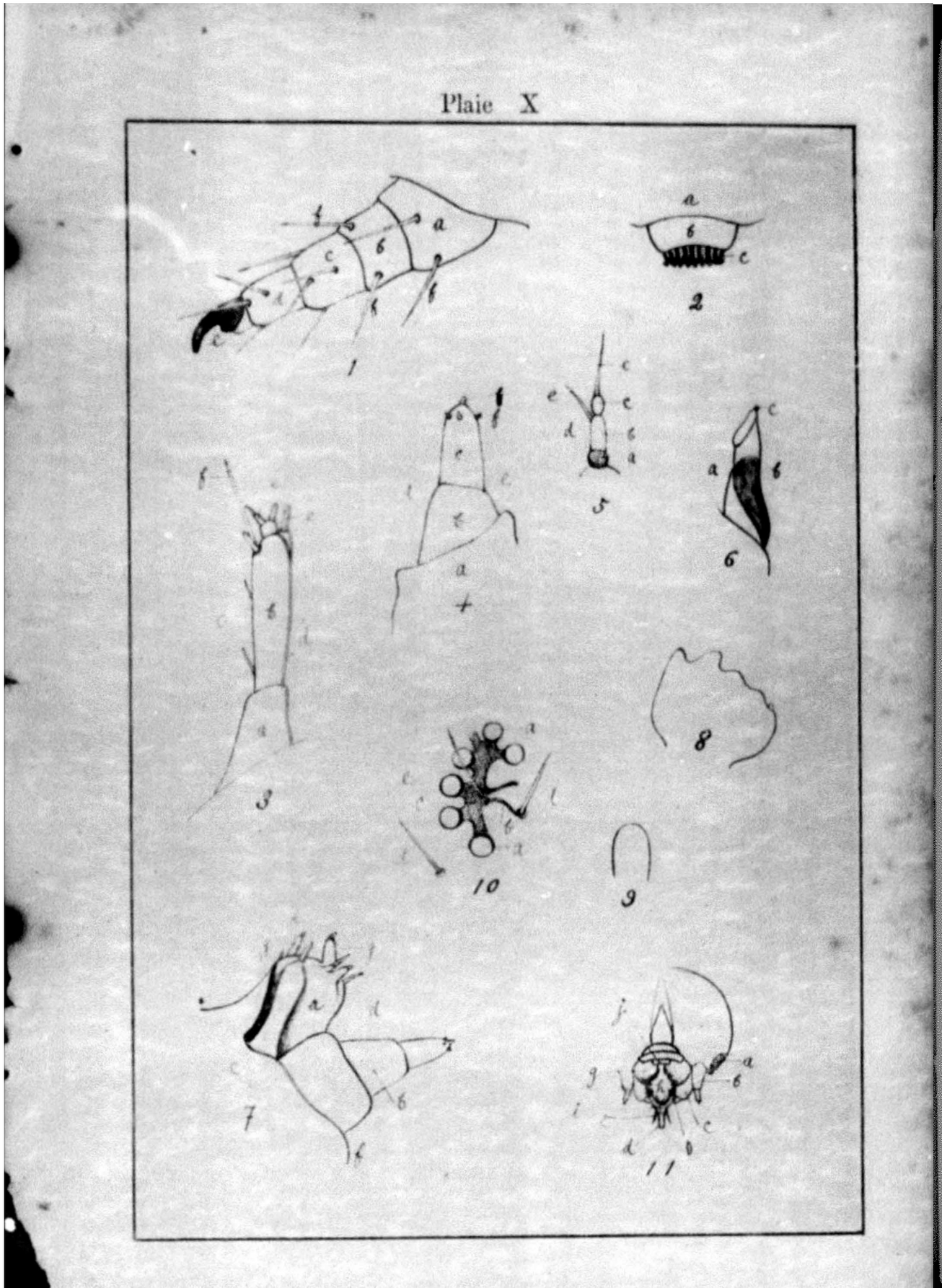
**Fig. 8.** Lateral view of the left mandible. (enlarged.)

**Fig. 9.** Dorsal view of the hypopharynx. (enlarged.)

**Fig. 10.** Eye spot.(enlarged.)
(a) Ocellus. (b) Nerves. (c) Coloured area.
(d) Fine hairs growing on the epidermis.
(e) Upper side.

**Fig. 11.** Dorsal view of the head. (enlarged.)
(a) Eye spot. (b) Antenna. (c) Maxillary palpus.

Plate X

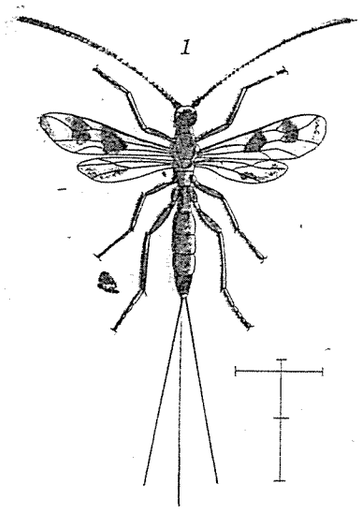


(d) Process of the labium. (e) Labial palpus.
(f) Maxilla. (g) Mandible. (h) Hypopharynx.
(i) Labium. (j) Labrum.

## PLATE XI.

**Fig. 1.** *Stenobracon maculata*, Matsum. (enlarged.)
**Fig. 2.** *Tetrastichus* sp. ( " )
**Fig. 3.** *Ceraphron beneficiens*, Zehn. ( " )
**Fig. 4.** *Phidole noda*, Smith. ( " )
**Fig. 5.** *Tetramorium guineense*, Fabr. ( " )
**Fig. 6.** *Paederus idae*, Lew. ( " )
**Fig. 7.** *Trichogramma japonicum*, Ash. ( " )

Plate XI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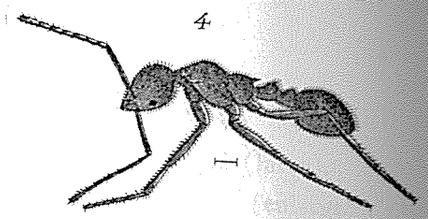
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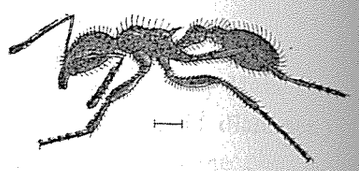
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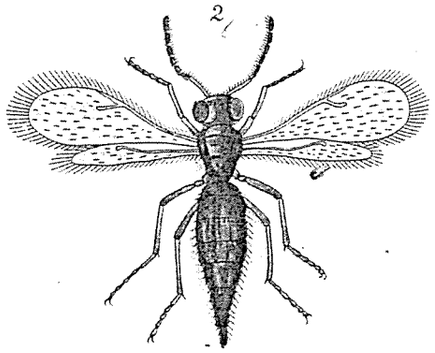
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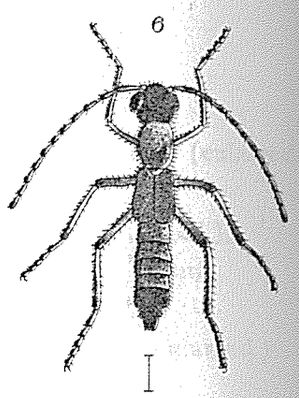
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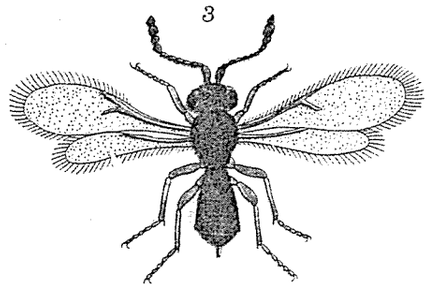
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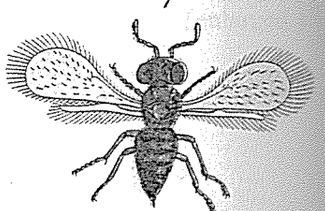
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## PLATE XII.

**Fig. 1.** *Shirakia dorsalis*, Mats., female. (enlarged.)

**Fig. 2.** " " " male. ( " )

**Fig. 3.** Front view of the head of *Shirakia dorsalis* (larva).
(a) Mouth parts. (enlarged)

**Fig. 4.** Ventral view of the anal apex of the same. ( " )
(a) Anus. (b) Process.

**Fig. 5.** Hind view of the same. (enlarged.)
(a) Anus.

**Fig. 6.** Dorsal view of the pupa of *Shirakia dorsalis*, Mats.
(12 times the natural size in diameter.)

**Fig. 7.** Ventral view of the pupal cocoon of the same.
(3 times the natural size in diameter.)
(a) Emergence-hole.

**Fig. 8.** Lateral view of the same. (enlarged.)
(a) Emergence-hole.

**Fig. 9.** *Amyosoma chilonis*, Vier., female. (enlarged.)

**Fig. 10.** Dorsal view of the larva of *Amyosoma chilonis*. (enlarged.)
(a) Head.

**Fig. 11.** Front view of the head of the same. (enlarged.)
(a) Labrum. (b) Labium. (c) Mouth.
(d) Antenna.

**Fig. 12.** Hind view of the anal area of the same. (enlarged.)
(a) Anus.

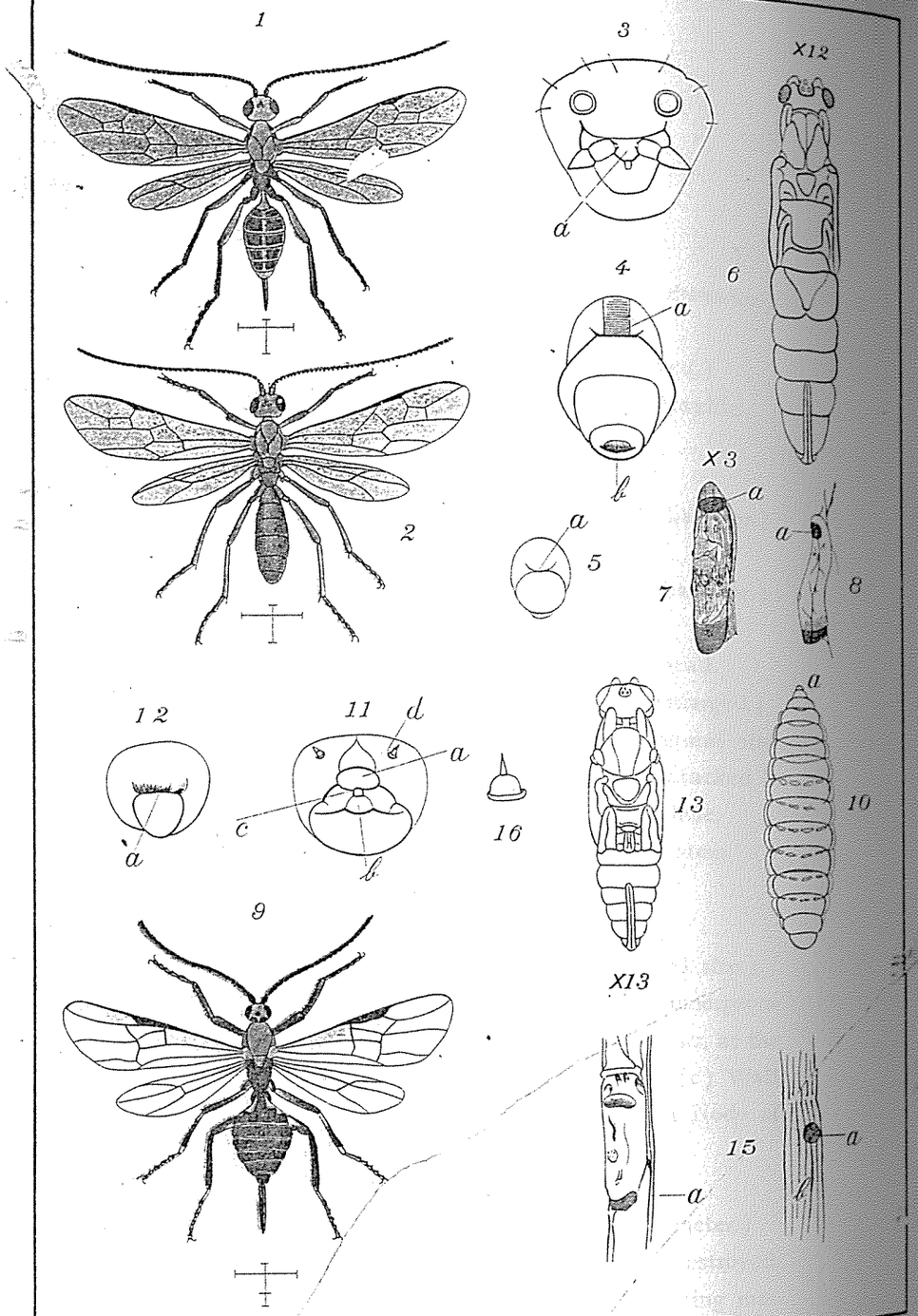
**Fig. 13.** Dorsal view of the pupa of the same.
(13 times the natural size in diameter.)

**Fig. 14.** Pupal cocoon of the same in the paddy stem. (enlarged.)
(a) Longitudinal section of the stem.

**Fig. 15.** Emergence hole bored through the stem wall by the same. (enlarged.)

**Fig. 16.** Antenna of the larva of the same. (enlarged.)

# Plate XII



## PLATE XIII.

**Fig. 1.** *Apanteles simplicis* Vier., female. (enlarged.)

**Fig. 2.** Lateral view of the larva of the same.
(10 times the natural size in diameter.)
(a) Head. (b) Anal end.

**Fig. 3.** Front view of the head of the same. (enlarged.)
(a) Antenna. (b) Eye spot. (c) Maxilla.
(d) Mandible.

**Fig. 4.** Lateral view of pupa of the same.
(6 times the natural size in diameter.)

**Fig. 5.** Dorsal view of the same.
(9 times the natural size in diameter.)

**Fig. 6.** Larval skin of the same. (enlarged.)

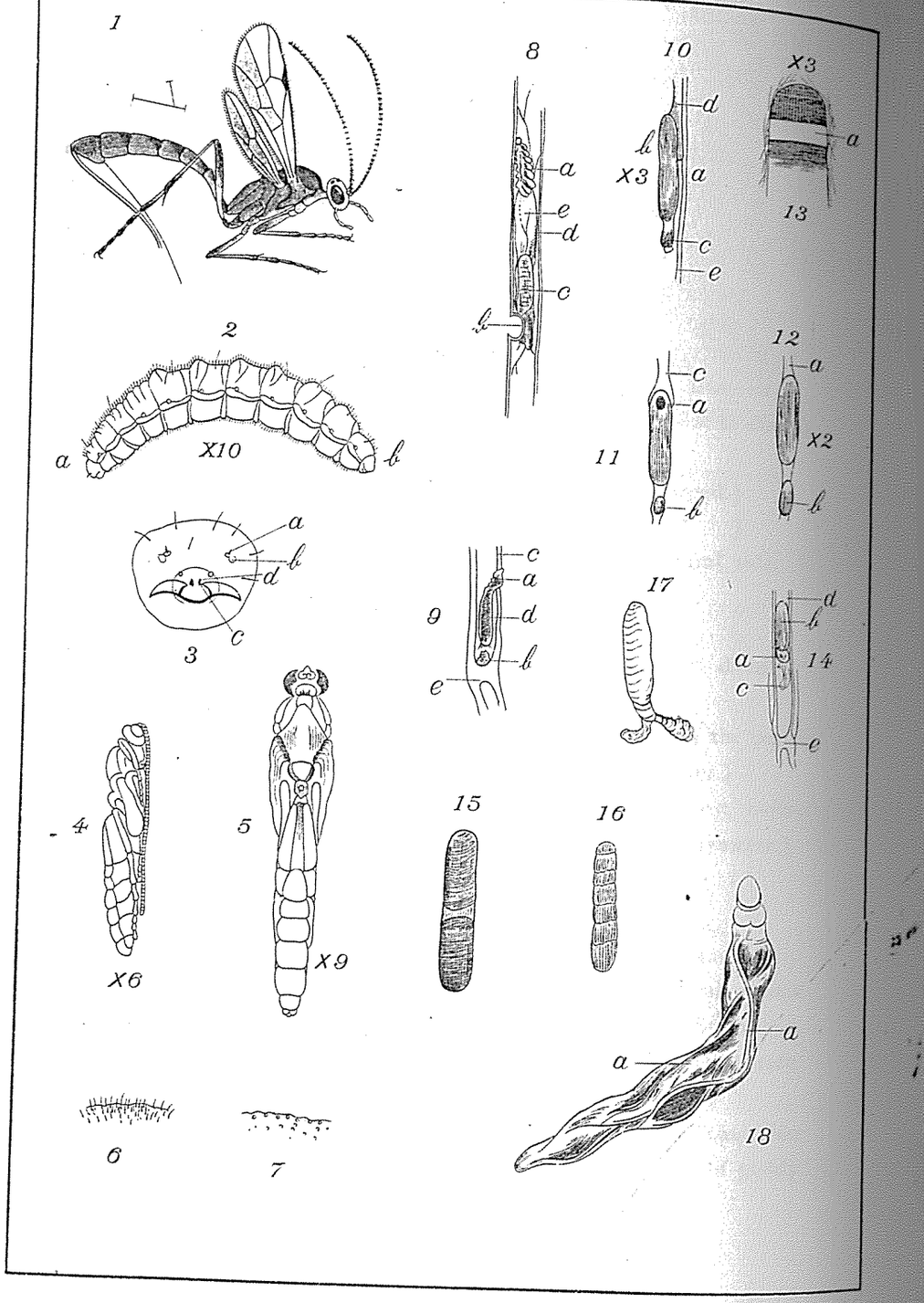
**Fig. 7.** Larval skin of the same in the region of the head.
(enlarged.)

**Fig. 8.** The larva of the same, in the paddy stem. (natural size.)
(a) Dead larva of *Schoenobius incertellus*, attacked by the larva of the same. (b) Emergence hole.
(c) Matured larva. (d) Wall of paddy stem.
(e) Cocoon.

**Fig. 9.** Pupal cocoon of the same in the paddy stem.
(natural size.)
(a) Apex of the cocoon protruding from the emergence hole. (b) Dead larva of *Schoenobius incertellus*, at the end of the pupal cocoon of the parasite. (c) Wall of paddy stem. (d) Pupal cocoon. (e) Node of paddy stem.

**Fig. 10.** Lateral view of pupal cocoon of the same.
(3 times the natural size in diameter.)
(a) Dorsal side. (b) Ventral side. (c) Destroyed larva of *Schoenobius incertellus*. (d) Connecting me-

# Plate XIII




mbrane between the cocoon and the stem wall.
(e) Wall of paddy.

**Fig. 11.** Ventral view of pupal cocoon of the same.
(3 times the natural size in diameter.)
(a) Emergence hole. (b) Destroyed larva of *Schoenobius incertellus.* (c) Connecting membrane between the cocoon and the stem wall.

**Fig. 12.** Ventral view of pupal cocoon of the same.
(twice the natural size in diameter.)
(a) Connecting membrane between the cocoon and the stem wall. (b) Destroyed larva of *Schoenobius incertellus.*

**Fig. 13.** Inner surface of pupal cocoon.
(3 times the natural size in diameter.)
(a) Colourless area.

**Fig. 14.** Pupal cocoon of the same, in the paddy stem.
(a) Destroyed larva of *Sch. incertellus.* (natural size.)
(b) Cocoon. (c) Cocoon spun by larva of *Sch. incertellus.* (d) Stem wall. (e) Node of stem.

**Fig. 15.** Large common pupal cocoon.
(3 times the natural size in diameter.)

**Fig. 16.** Uncommon pupal cocoon. (enlarged.)

**Fig. 17.** Unknown substance kept in the liquid at the end of the pupal cocoon. (enlarged.)

**Fig. 18.** Larva of *Sch. incertellus*, attacked by *Gordius sp.*
(a) *Gordius*, seen from the outside of the larva.

## PLATE XII.

Fig. 1. *Eripternus* [illegible] (enlarged.)

Fig. 2. The male of the [illegible] ( " )

Fig. 3. The female of the [illegible] ( " )

Fig. 4. Dorsal view of the pupa of the same.

([illegible] the natural size in diameter.)

Fig. 5. Lateral view of the pupa of the same.

([illegible] the natural size in diameter.)

Fig. 6. Pupal cocoon of the same. (twice the nat. size in diam.)

(a) Emergence hole.

Fig. 7. *Eripternus* (?) *abscissis*, n. sp., female. (enlarged.)

Fig. 8. Lateral view of the larva of the same. ( " )

(a) Antenna. (b) Mouth. (c) Ventral side.

(d) Dorsal side.

Fig. 9. Front view of the head of the same.

(38 times the nat. size in diam.)

(a) Mandible. (b) Maxilla.

Fig. 10. Substance contained in the liquid at the end of the pupal cocoon. (13 times the nat. size in diameter.)

Fig. 11. Old skin of the larva of the same, moulted just before pupation. (390 times the natural size in diameter.)

(a) Head.

Fig. 12. Lateral view of the pupal cocoon of the same.

(3 times the nat. size in diameter.)

(a) Connecting membrane between the pupal cocoon and the wall of the paddy stem. (b) Stem wall. (c) End portion containing a liquid. (d) Dorsal side.

Fig. 13. Pupal cocoon in the paddy stem. (natural size.)

(a) Emergence hole bored by the larva of *Schoenobius incertellus*. (b) Pupal cocoon. (c) Node of paddy stem.

Plate XIV

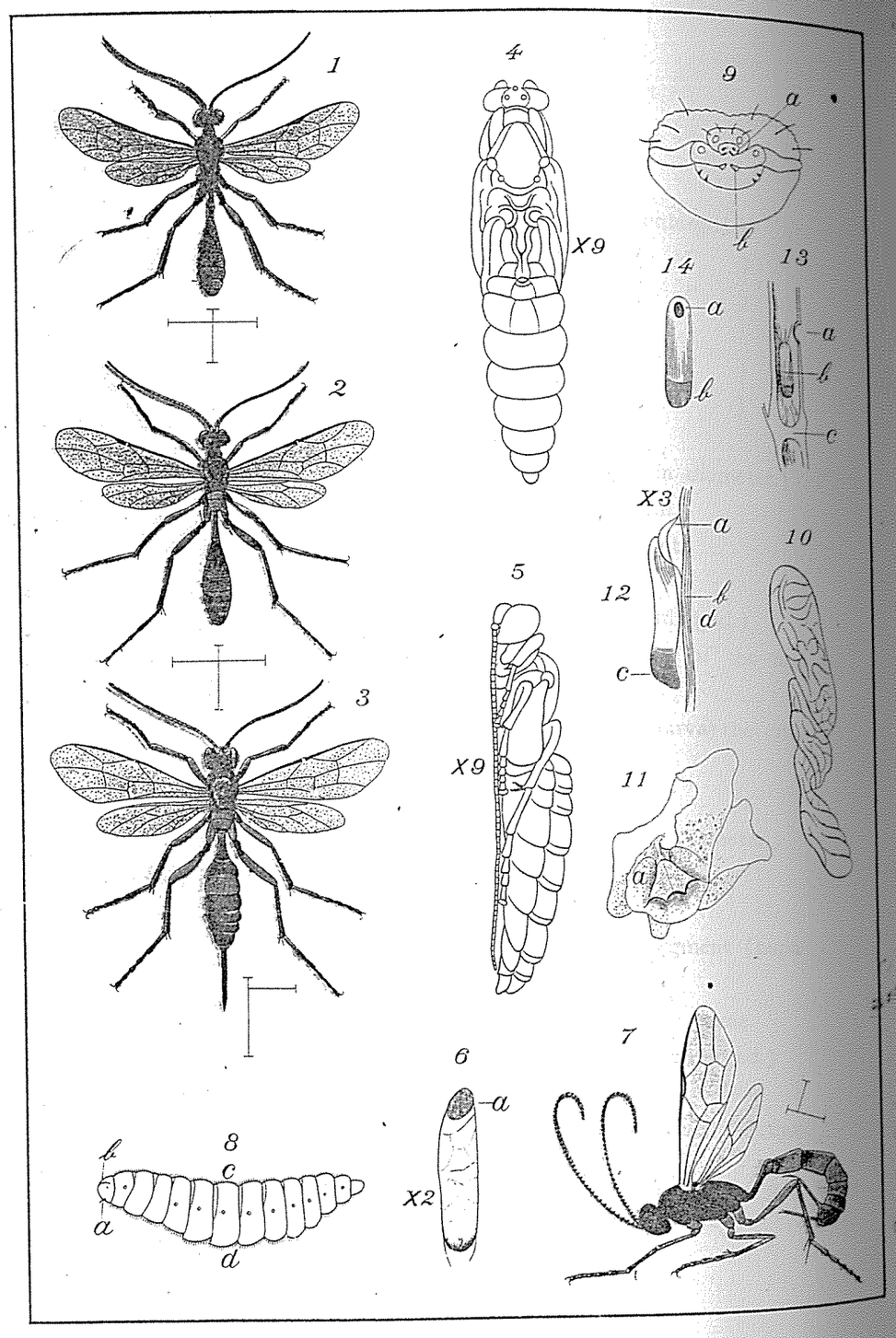



**Fig. 14.** Ventral view of the pupal cocoon.
(twice the natural size in diameter.)
(a) Emergence hole. (b) Anal end.

## PLATE XV.

**Fig. 1.** *Trathala* (?) *flavopedes*, n. sp., male. (enlarged.)

**Fig. 2.** *Aphiochaeta parasitica*, n. sp., male. ( " )

**Fig. 3.** Dorsal view of the larva of the same. ( " )
(a) Head. (b) Anal end.

**Fig. 4.** Dorsal view of the pupa of the same. ( " )

**Fig. 5.** *Anatrichus erinaceus* Loew. female. ( " )

**Fig. 6.** Lateral view of the larva of the same.
(8 times the natural size in diameter.)
(a) Lateral process of the first segment.
(b) Lateral process of the anal segment.
(c) Dorsal side.

**Fig. 7.** Lateral view of the head of the same. (enlarged.)
(a) Antenna. (b) Lateral process of the first segment. (c) Head.

**Fig. 8.** Lateral view of lateral process of (pupa and larva) the anal segment of the same. (enlarged.)

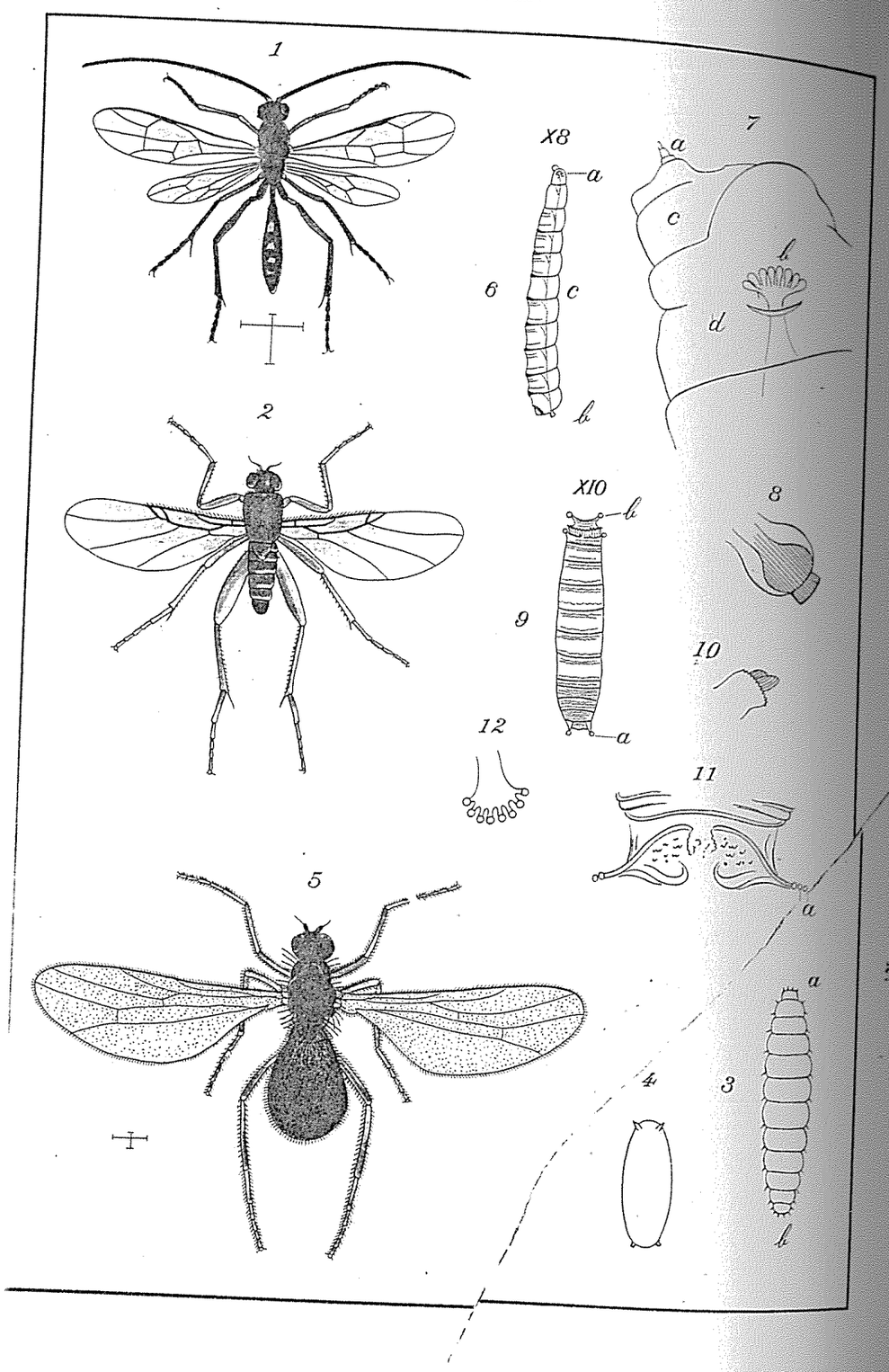
**Fig. 9.** Dorsal view of the pupa of the same.
(10 times the natural size in diameter.)
(a) Lateral process of the first segment.
(b) Lateral process of the anal segment.

**Fig. 10.** Dorsal view of lateral process of the anal segment (pupa and larva) of the same. (enlarged.)

**Fig. 11.** Dorsal view of the apex of the pupa of the same.
(enlarged.)
(a) Lateral process of the first segment.

**Fig. 12.** Lateral view of lateral process of the first segment of the pupa and larva. (enlarged.)

Plate XV

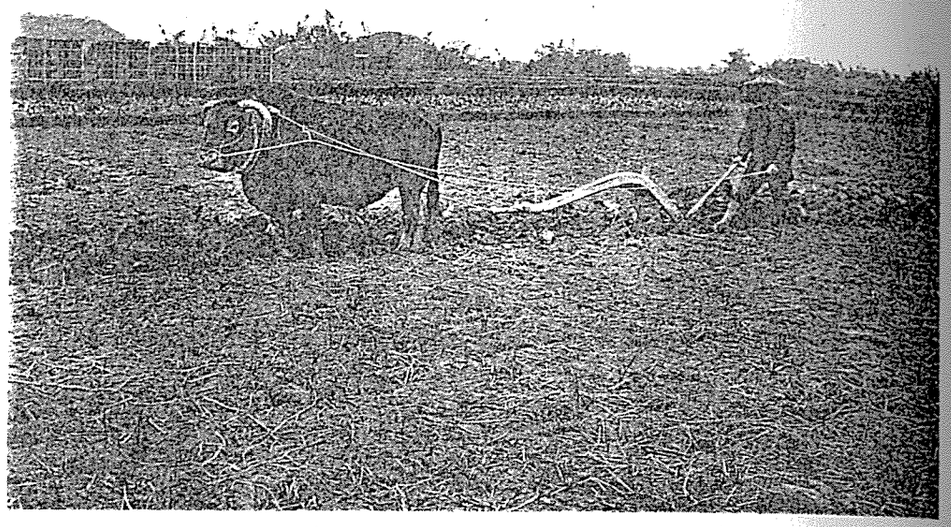


## PLATE XVI.

**Fig. I.** Ploughing.

**Fig. II.** Pulling-up the paddy stumps.

Flate XVI



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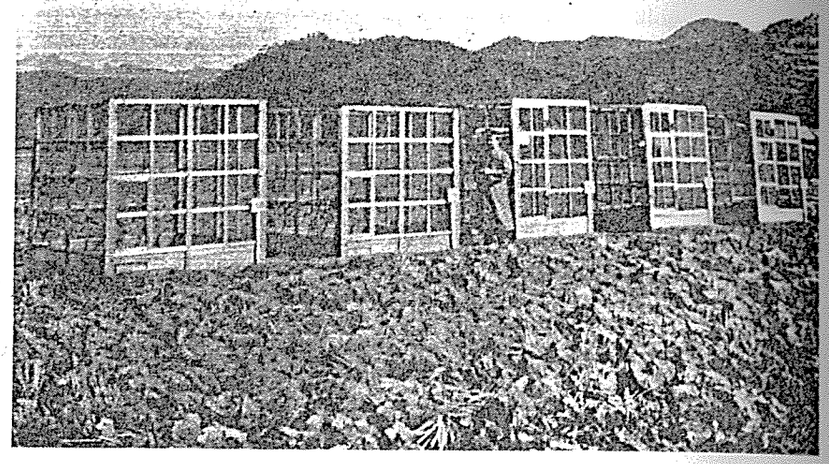
## PLATE XVII.

**Fig. I.** Large breeding cage, used in the field.

**Fig. II.** Small breeding cage, used in the field.

Plate XVII



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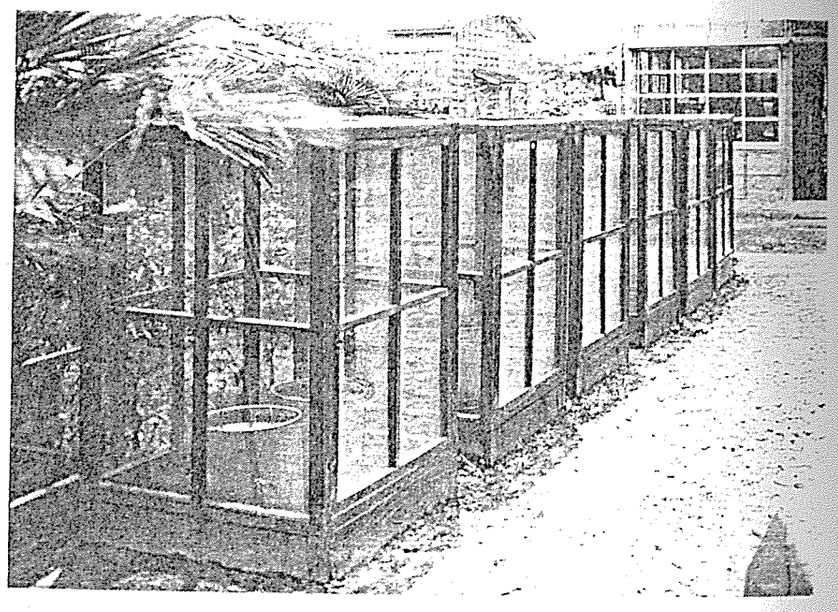

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## PLATE XVIII.

**Fig. I.** Burning the paddy stubble, after pulling-up.

**Fig. II.** Burying the paddy stubble, after pulling-up.

Plate XVIII

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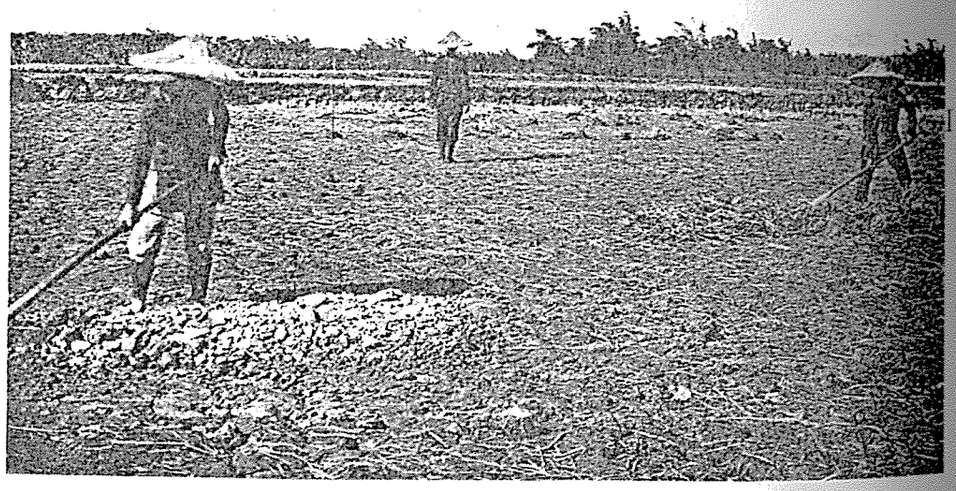

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## PLATE XIX.

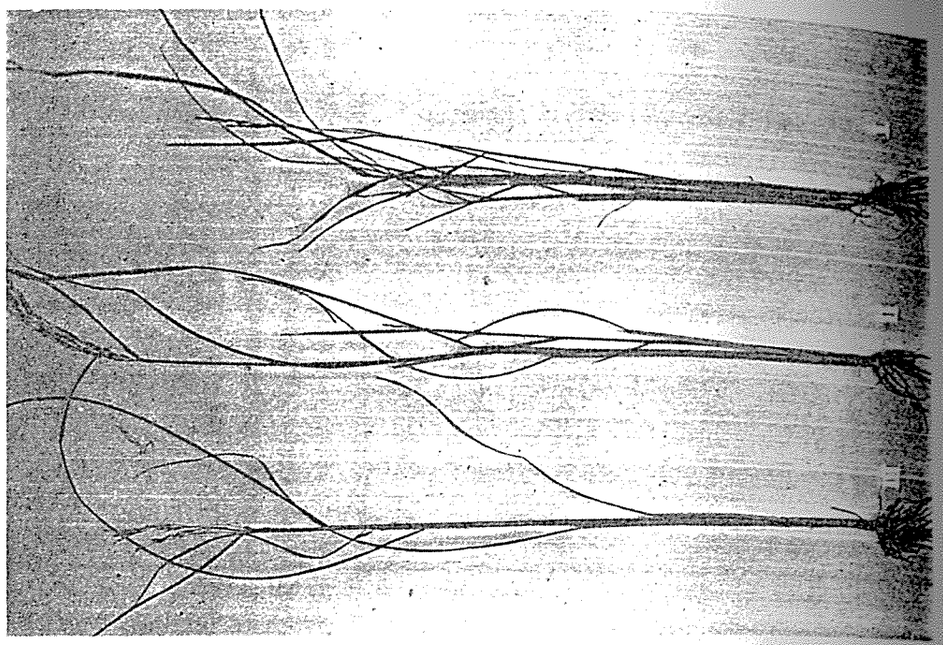
**Fig. I.** Paddy plant injured by *Schoenobius incertellus*, at the young time, showing temporary tillering.

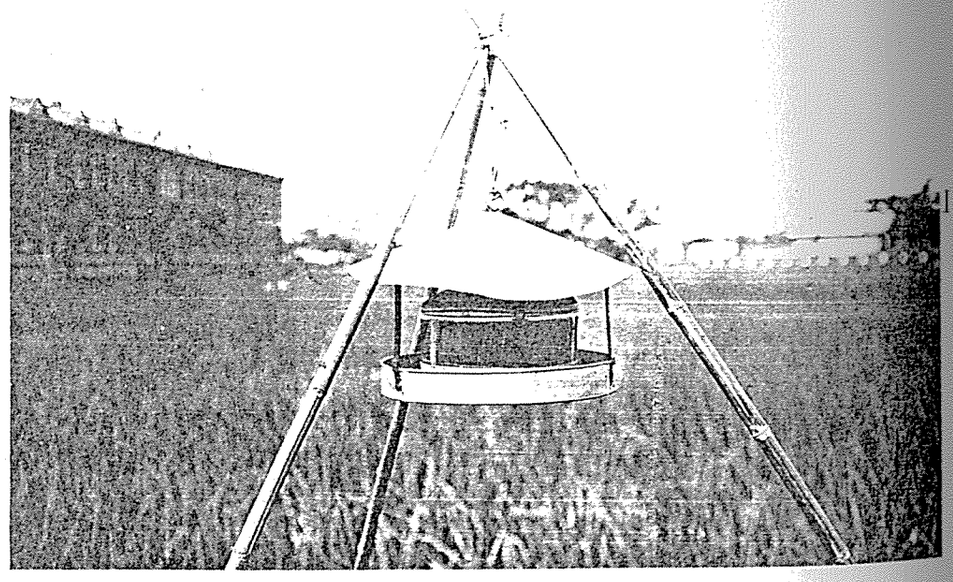
**Fig. II.** Paddy plant. (uninjured.)

**Fig. III.** Paddy plant injured by *Sch. incertellus*, just before the shooting time, showing the white ears.

**Fig. IV.** Cage used for protecting the emergence of parasitic Hymenoptera.

Plate XIX



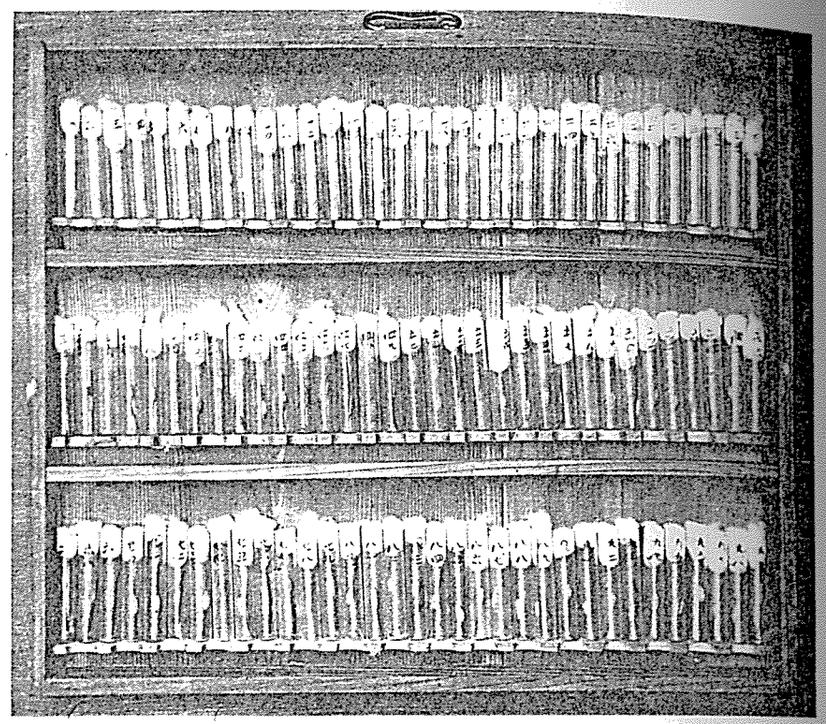


## PLATE XX.

**Fig. I.** Investigation of egg-parasite.

**Fig. II.** Breeding of parasitic Hymenoptera.

Plate XX



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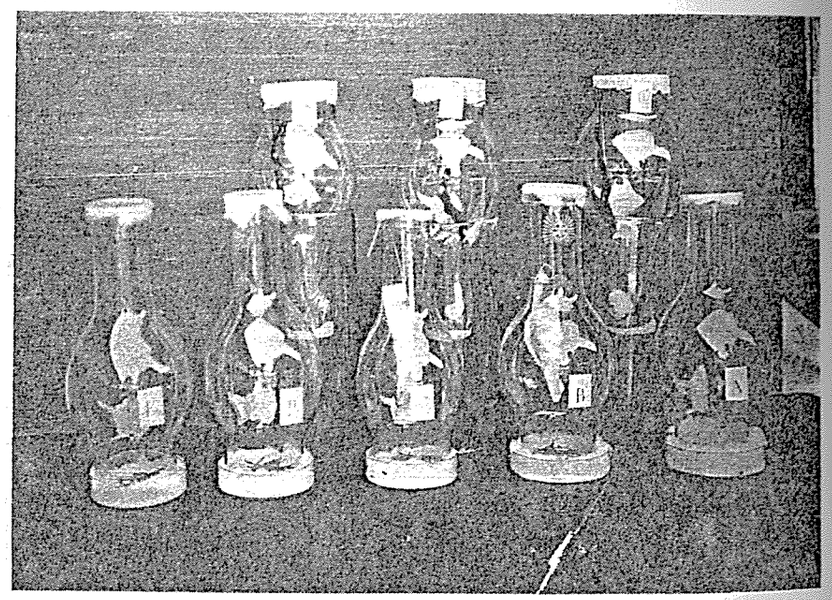

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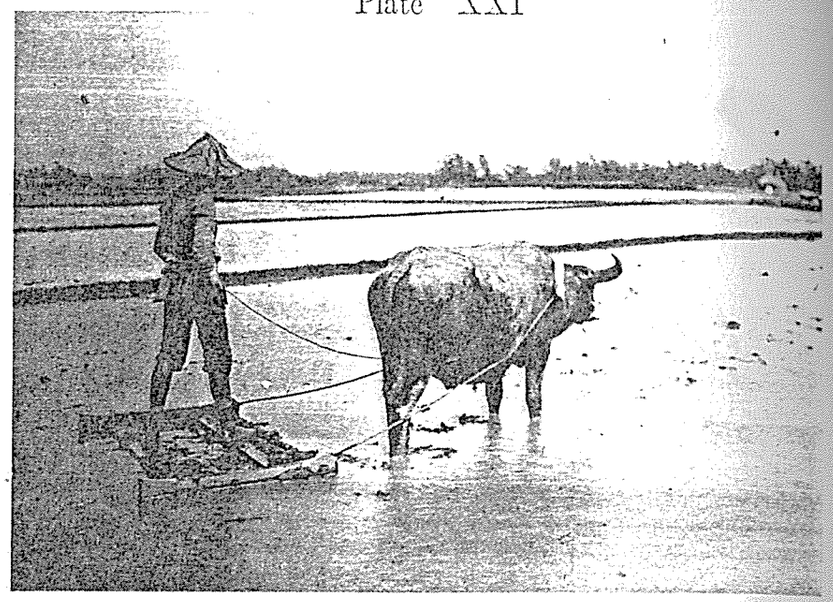
## PLATE XXI.

**Fig. I.** Submerging paddy stubble by means of ploughing, irrigating and harrowing.

**Fig. II.** Experimental field ; to ascertain whether the moth could emerge from the larva remaining still in the stubble (in soil), after cutting the stubble.

Plate XXI



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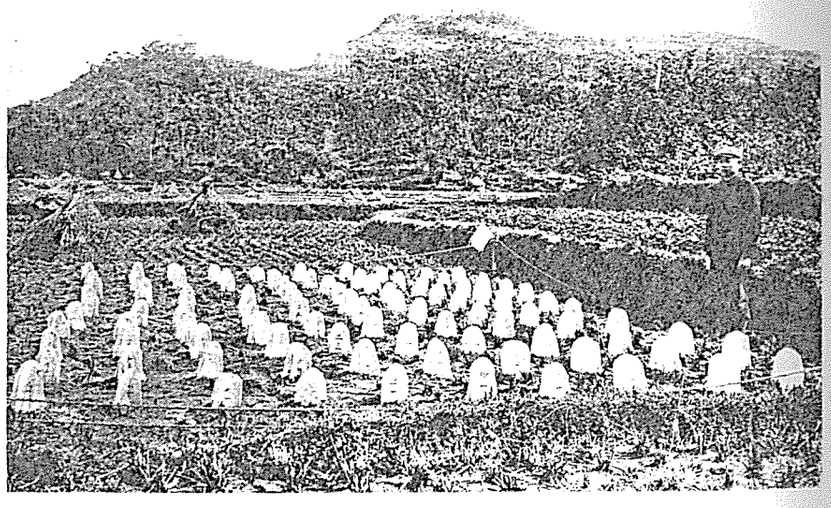

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## PLATE XXII.

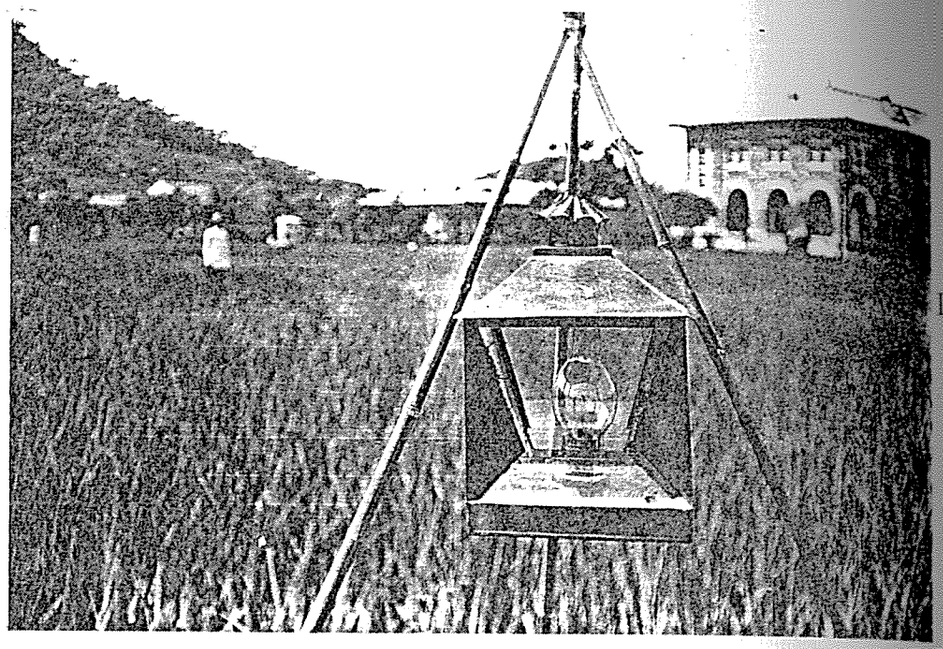
**Fig. I.** Trap-lantern, used in my investigations.

**Fig. II.** Instruments for cutting the paddy stalks :—

(a) without a spring.

(b) with a spring.

Plate XXII



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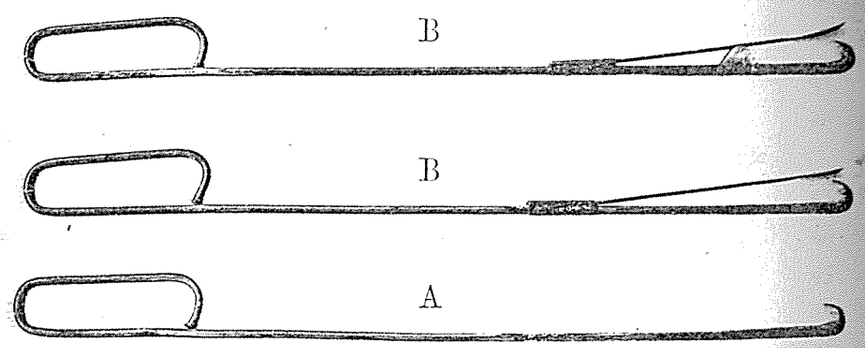


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